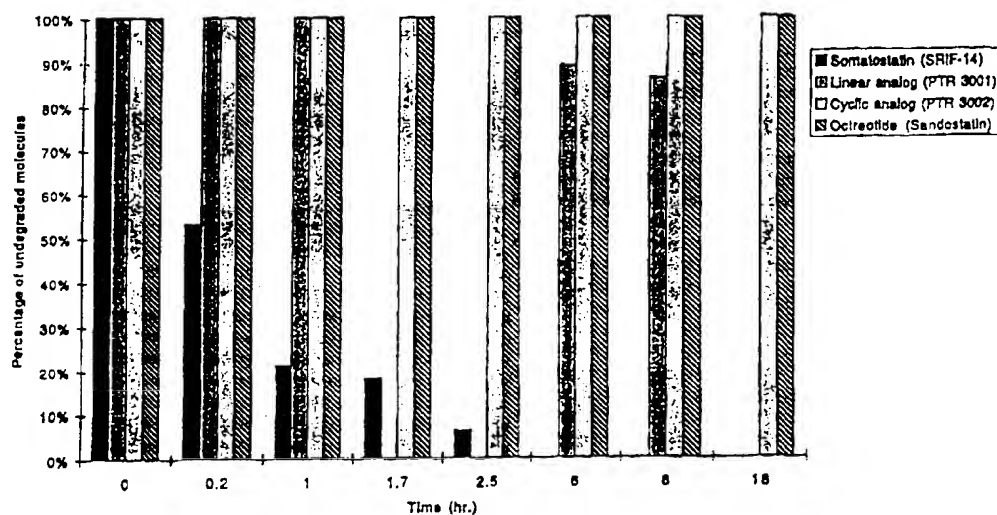




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(54) Title: CONFORMATIONALLY CONSTRAINED BACKBONE CYCLIZED PEPTIDE ANALOGS



(57) Abstract

The invention relates to cyclic peptide analogs. The active terminal functional groups are protected by specific protecting groups that are easily removed to effect either backbone-to-backbone or backbone-to-side chain cyclizations. The invention is exemplified by backbone cyclized bradykinin antagonists having biological activity. Further embodiments of the invention are somatostatin analogs having one or two ring structures involving backbone cyclization.

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CONFORMATIONALLY CONSTRAINED BACKBONE CYCLIZED PEPTIDE ANALOGS

5

## FIELD OF THE INVENTION

The present invention relates to conformationally constrained N<sup>α</sup> backbone-cyclized peptide analogs cyclized via novel non-peptidic linkages, to novel N<sup>α</sup>,ω-functionalized amino acid building units, to processes for the preparation of these backbone cyclized peptides and building units, to methods for using these peptide analogs and to pharmaceutical compositions containing same.

15

## BACKGROUND OF THE INVENTION

Peptidomimetics

As a result of major advances in organic chemistry and in molecular biology, many bioactive peptides can now be prepared in quantities sufficient for pharmacological and clinical utilities. Thus in the last few years new methods have been established for the treatment and therapy of illnesses in which peptides have been implicated. However, the use of peptides as drugs is limited by the following factors: a) their low metabolic stability towards proteolysis in the gastrointestinal tract and in serum; b) their poor absorption after oral ingestion, in particular due to their relatively high molecular mass or the lack of specific transport systems or both; c) their rapid excretion through the liver and kidneys; and d) their undesired side effects in non-target organ systems, since peptide receptors can be widely distributed in an organism.

Moreover, with few exceptions, native peptides of small to medium size (less than 30-50 amino acids) exhibit undesired selectivity, metabolic susceptibilities and hamper attempts to

determine the biologically active conformation. If a peptide has the biologically active conformation per se, i.e., receptor-bound conformation, then an increased affinity toward the receptor is expected, since the decrease in entropy on  
5 binding is less than that on the binding of a flexible peptide. It is therefore important to strive for and develop ordered, uniform and biologically active peptides.

In recent years, intensive efforts have been made to develop peptidomimetics or peptide analogs that display more  
10 favorable pharmacological properties than their prototype native peptides. The native peptide itself, the pharmacological properties of which have been optimized, generally serves as a lead for the development of these peptidomimetics. However, a major problem in the development  
15 of such agents is the discovery of the active region of a biologically active peptide. For instance, frequently only a small number of amino acids (usually four to eight) are responsible for the recognition of a peptide ligand by a receptor. Once this biologically active site is determined a  
20 lead structure for development of peptidomimetic can be optimized, for example by molecular modeling programs.

As used herein, a "peptidomimetic" is a compound that, as a ligand of a receptor, can imitate (agonist) or block (antagonist) the biological effect of a peptide at the  
25 receptor level. The following factors should be considered to achieve the best possible agonist peptidomimetic a) metabolic stability, b) good bioavailability, c) high receptor affinity and receptor selectivity, and d) minimal side effects.

From the pharmacological and medical viewpoint it is  
30 frequently desirable to not only imitate the effect of the peptide at the receptor level (agonism) but also to block the receptor when required (antagonism). The same pharmacological considerations for designing an agonist peptidomimetic mentioned above hold for designing peptide antagonists but



unequivocally clear which factors are decisive for the agonistic effect and which are for the antagonistic effect.

A generally applicable and successful method recently has been the development of conformationally restricted

5 peptidomimetics that imitate the receptor-bound conformation of the endogenous peptide ligands as closely as possible (Rizo and Gierasch, Ann. Rev. Biochem., 61:387, 1992).

Investigations of these types of analogs show them to have increased resistance toward proteases, that is, an increase in  
10 metabolic stability, as well as increased selectivity and thereby fewer side effects (Veber and Friedinger, Trends Neurosci., p. 392, 1985).

Once these peptidomimetic compounds with rigid conformations are produced, the most active structures are  
15 selected by studying the conformation-activity relationships. Such conformational constraints can involve short range (local) modifications of structure or long range (global) conformational restraints (for review see Giannis and Kolter, Angew. Chem. Int. Ed. Engl. 32:1244, 1993).

## 20 Conformationally constrained peptides

Bridging between two neighboring amino acids in a peptide leads to a local conformational modification, the flexibility of which is limited in comparison with that of regular dipeptides. Some possibilities for forming such bridges  
25 include incorporation of lactams and piperazinones.  $\gamma$ -Lactams and  $\delta$ -lactams have been designed to some extent as "turn mimetics"; in several cases the incorporation of such structures into peptides leads to biologically active compounds.

30 Global restrictions in the conformation of a peptide are possible by limiting the flexibility of the peptide strand through cyclization (Hruby et al., Biochem. J., 268:249, 1990). Not only does cyclization of bioactive peptides improve their metabolic stability and receptor selectivity

analysis. The common modes of cyclization are the same found

in naturally occurring cyclic peptides. These include side chain to side chain cyclization or side chain to end-group cyclization. For this purpose, amino acid side chains that are not involved in receptor recognition are connected together or to the peptide backbone. Another common cyclization is the end-to-end cyclization.

Three representative examples are compounds wherein partial structures of each peptide are made into rings by linking two penicillamine residues with a disulfide bridge (Mosberg et al., P.N.A.S. US, 80:5871, 1983), by formation of an amide bond between a lysine and an aspartate group (Charpentier et al., J. Med. Chem. 32:1184, 1989), or by connecting two lysine groups with a succinate unit (Rodriguez et al., Int. J. Pept. Protein Res. 35:441, 1990). These structures have been disclosed in the literature in the case of a cyclic enkephalin analog with selectivity for the  $\delta$ -opiate receptor (Mosberg et al., *ibid.*); or as agonists to the cholecystokinin B receptor, found largely in the brain (Charpentier et al., *ibid.*, Rodriguez et al., *ibid.*).

The main limitations to these classical modes of cyclization are that they require substitution of amino acid side chains in order to achieve cyclization.

Another conceptual approach to the conformational constraint of peptides was introduced by Gilon, et al., (Biopolymers, 31:745, 1991) who proposed backbone to backbone cyclization of peptides. The theoretical advantages of this strategy include the ability to effect cyclization via the carbons or nitrogens of the peptide backbone without interfering with side chains that may be crucial for interaction with the specific receptor of a given peptide. While the concept was envisaged as being applicable to any linear peptide of interest, in point of fact the limiting factor in the proposed scheme was the availability of suitable building units that must be used to replace the amino acids

any practical method

of preparing building units of amino acids other than glycine (Gilon et al., J. Org. Chem., 587:5687, 1992). While analogs of other amino acids were attempted the synthetic method used was unsuccessful or of such low yield as to preclude any  
5 general applicability.

In Gilon, EPO Application No. 564,739 A2; and J. Org. Chem., 57:5687, 1992, two basic approaches to the synthesis of building units are described. The first starts with the reaction of a diamine with a general  $\alpha$  bromo acid. Selective  
10 protection of the  $\omega$  amine and further elaborations of protecting groups provides a building unit, suitable for Boc chemistry peptide synthesis. The second approach starts with selective protection of a diamine and reaction of the product with chloroacetic acid to provide the protected glycine  
15 derivative, suitable for Fmoc peptide synthesis.

Both examples deal with the reaction of a molecule of the general type  $X-CH(R)-CO-OR'$  (wherein X represents a leaving group which, in the examples given, is either Br or Cl) with an amine which replaces the X. The amine bears an alkylidene  
20 chain which is terminated by another functional group, amine in the examples described, which may or may not be blocked by a protecting group.

In all cases the  $\alpha$  nitrogen of the end product originates in the molecule which becomes the bridging chain for  
25 subsequent cyclization. This approach was chosen in order to take advantage of the higher susceptibility to nucleophilic displacement of a leaving group next to a carboxylic group.

In a molecule where R is different than hydrogen there is a high tendency to eliminate HX under basic conditions. This  
30 side reaction reduces the yield of Gilon's method to the point where it is impractical for production of building units based on amino acids other than glycine. The diamine nitrogen is primary while the product contains a secondary nitrogen, which is a better nucleophile. So while the desired reaction may be

the synthesis of building units with end group chemistries other

than nitrogen, so the only cyclization schemes possible are backbone to side chain and backbone to C terminus.

Applications of conformationally constrained peptides

Conformationally constrained peptides find many  
5 pharmacological uses. Somatostatin is a cyclic  
tetradecapeptide found both in the central nervous system and  
in peripheral tissues. It was originally isolated from  
mammalian hypothalamus and identified as an important  
inhibitor of growth hormone secretion from the anterior  
10 pituitary. Its multiple biological activities include  
inhibition of the secretion of glucagon and insulin from the  
pancreas, regulation of most gut hormones and regulation of  
the release of other neurotransmitters involved in motor  
activity and cognitive processes throughout the central  
15 nervous system (for review see Lamberts, Endocrine Rev.,  
9:427, 1988).

Natural somatostatin (also known as Somatotropin Release  
Inhibiting Factor, SRIF) of the following structure:

20 H-Ala<sup>1</sup>-Gly<sup>2</sup>-Cys<sup>3</sup>-Lys<sup>4</sup>-Asn<sup>5</sup>-Phe<sup>6</sup>-Phe<sup>7</sup>-Trp<sup>8</sup>-Lys<sup>9</sup>-Thr<sup>10</sup>-Phe<sup>11</sup>-Thr<sup>12</sup>-  
Ser<sup>13</sup>-Cys<sup>14</sup>-OH

was first isolated by Guillemin and colleagues (Bruzeau *et al.*  
Science, 179:78, 1973). In its natural form, it has limited  
25 use as a therapeutic agent since it exhibits two undesirable  
properties: poor bioavailability and short duration of action.  
For this reason, great efforts have been made during the last  
two decades to find somatostatin analogs that will have  
superiority in either potency, biostability, duration of  
30 action or selectivity with regard to inhibition of the release  
of growth hormone, insulin or glucagon.

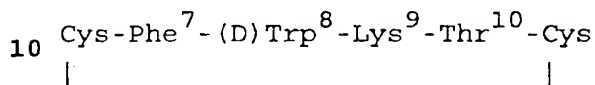
Structure-activity relation studies, spectroscopic  
techniques such as circular dichroism and nuclear magnetic  
resonance, and molecular modeling approaches reveal the

the role of each amino acid in stabilizing the

pharmacophore conformation through hydrophobic interactions between the two aromatic rings; the four amino acids Phe<sup>7</sup>-Trp<sup>8</sup>-Lys<sup>9</sup>-Thr<sup>10</sup> which are spread around the  $\beta$ -turn in the antiparallel  $\beta$ -sheet are essential for the pharmacophore; and

5 (D)Trp<sup>8</sup> is almost always preferable to (L)Trp<sup>8</sup>.

Nevertheless, a hexapeptide somatostatin analog containing these four amino acids anchored by a disulfide bridge:

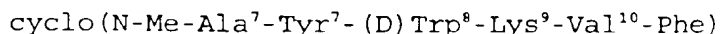


is almost inactive both *in vitro* and *in vivo*, although it has the advantage of the covalent disulfide bridge which replaces  
 15 the Phe<sup>6</sup>-Phe<sup>11</sup> hydrophobic interactions in natural somatostatin.

Four main approaches have been attempted in order to increase the activity of this hexapeptide somatostatin analog.

(1) Replacing the disulfide bridge by a cyclization which  
 20 encourages a cis-amide bond, or by performing a second cyclization to the molecule yielding a bicyclic analog. In both cases the resultant analog has a reduced number of conformational degrees of freedom. (2) Replacing the original amino acids in the sequence Phe<sup>7</sup>-(D)Trp<sup>8</sup>-Lys<sup>9</sup>-Thr<sup>10</sup> with more  
 25 potent amino acid analogs, such as replacing Phe<sup>7</sup> with Tyr<sup>7</sup> and Thr<sup>10</sup> with Val<sup>10</sup>. (3) Incorporating additional structural elements from natural somatostatin with the intention that these new elements will contribute to the interaction with the receptor. (4) Eliminating one of the four amino acids  
 30 Phe<sup>7</sup>-(D)Trp<sup>8</sup>-Lys<sup>9</sup>-Thr<sup>10</sup> with the assumption that such analogs would be more selective.

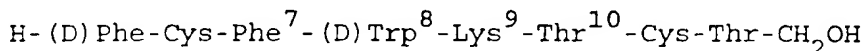
The somatostatin analog, MK-678:



The first three approaches above (Faber, et al., 1986)

Science, 34:371, 1984). In this hexapeptide analog, a cis-amide bond is located between N-Me-Ala and Phe<sup>11</sup>, Tyr<sup>7</sup> and Val<sup>10</sup> replace Phe<sup>7</sup> and Thr<sup>10</sup> respectively, and Phe<sup>11</sup> is incorporated from natural somatostatin.

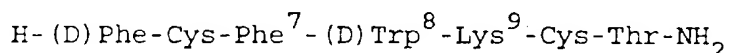
- 5 Another group of somatostatin analogs (U.S. patents 4,310,518 and 4,235,886) includes octreotide:



- 10 the only somatostatin analog currently available. It was developed using the third approach described above. Here, (D)Phe<sup>5</sup> and the reduced C-terminal Thr<sup>12</sup>-CH<sub>2</sub>OH are assumed to occupy some of the conformational space available to the natural Phe<sup>6</sup> and Thr<sup>12</sup>, respectively.

15

The compound TT2-32:



20

is closely related to octreotide and is an example of implementing the fourth approach described above. The lack of Thr<sup>10</sup> is probably responsible for its high selectivity in terms of antitumor activity.

25

These examples of highly potent somatostatin analogs indicate that the phenylalanines in positions 6 and 11 not only play an important role in stabilizing the pharmacophore conformation but also have a functional role in the interaction with the receptor. It is still an open question whether one phenylalanine (either Phe<sup>6</sup> or Phe<sup>11</sup>) is sufficient for the interaction with the receptor or whether both are needed.

30

It is now known that the somatostatin receptors constitute a family of five different receptor subtypes (Bell and Reisine, *Trends Neurosci.* 16: 111, 1993).

may not provide sufficient selectivity or receptor subtype selectivity, particularly as anti-neoplastic agents (Reubi and Laissue, TIPS, 16, 110-115, 1995).

Symptoms associated with metastatic carcinoid tumors (flushing and diarrhea) and vasoactive intestinal peptide (VIP) secreting adenomas (watery diarrhea) are treated with somatostatin analogs. Somatostatin has been also approved for the treatment of severe gastrointestinal hemorrhages. Somatostatin may also be useful in the palliative treatment of other hormone-secreting tumors (e.g., pancreatic islet-cell tumors and acromegaly) and hormone dependent tumors (e.g., chondrosarcoma and osteosarcoma) due to its anti-secretory activity.

Another important peptide, Bradykinin, is a naturally occurring nonapeptide, Arg<sup>1</sup>-Pro<sup>2</sup>-Pro<sup>3</sup>-Gly<sup>4</sup>-Phe<sup>5</sup>-Ser<sup>6</sup>-Pro<sup>7</sup>-Phe<sup>8</sup>-Arg<sup>9</sup>, formed and released from precursors in the blood in response to inflammatory stimuli. Elevated levels of bradykinin also appear in other body fluids and tissues in pathological states such as asthma, septic shock and common cold. No clinical abnormalities have been associated so far with bradykinin deficiency which indicates that bradykinin may not play a critical role in normal physiology.

However, bradykinin mediates its physiological activities by binding to a specific receptive molecule called the bradykinin receptor. Two such bradykinin receptors have been identified so far (these are called B1 and B2 receptors). Subsequent to binding, the bradykinin signal transduction pathway includes production of prostaglandins and leukotrienes as well as calcium activation. Through these mediators, bradykinin is involved in pain, inflammation, allergic reactions and hypotension. Therefore, a substance that can block the ability of bradykinin to bind to its receptor, namely a bradykinin antagonist, should have a significant

The analog used herein to exemplify backbone cyclization is:

D-Arg<sup>0</sup>-Arg-R<sup>1</sup>-Hyp<sup>3</sup>-Gly-Phe-R<sup>2</sup>-D-Phe-Phe<sup>7</sup>-Arg

(wherein, R<sup>1</sup> is Pro, R<sup>2</sup> is Ser in native bradykinin). The  
5 change of proline at position 7 of native bradykinin to D-Phe  
confers antagonist activity. This compound was described in  
Steranka, et al., P.N.A.S. U.S., 85:3245-3249, 1988 and is one  
of a plethora of candidate sequences for modification by the  
current technology, i.e. backbone cyclization. In this  
10 regard, it is worth noting the applications: WO 89/01781, EP-  
A-0370453 and EP-A-0334244 which disclose a wide range of  
candidate structures. Antagonist peptides on which stability  
and/or tissue selectivity can be conferred by appropriate  
cyclization will be selected from the many such known  
15 sequences.

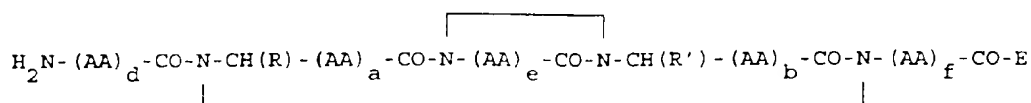
According to the present invention a novel synthetic  
approach is disclosed providing N<sup>ω</sup>(ω(functionalized)alkylene)  
amino acid building units that can be used to synthesize novel  
N<sup>ω</sup>-backbone cyclized peptide analogs such as, but not limited  
20 to, novel somatostatin and bradykinin analogs. None of the  
above-mentioned references teaches or suggests N<sup>ω</sup>-  
(ω(functionalized)alkylene) amino acids or the novel N<sup>ω</sup>-  
backbone cyclized peptide analogs of the present invention.

25

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide  
backbone cyclized peptide analogs that comprise peptide  
sequences which incorporate at least two building units, each  
30 of which contains one nitrogen atom of the peptide backbone  
connected to a bridging group as described below. In the  
present invention, one or more pairs of the building units is  
joined together to form a cyclic structure. Thus, according  
to one aspect of the present invention, backbone cyclized



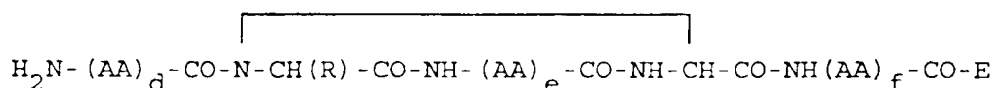


## Formula (I)

5 wherein: a and b each independently designates an integer from 1 to 8 or zero; d, e, and f each independently designates an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same  
 10 or different; E represents a hydroxyl group, a carboxyl protecting group or an amino group, or CO-E can be reduced to CH<sub>2</sub>-OH; R and R' each designates an amino acid side-chain such as H, CH<sub>3</sub>, etc., optionally bound with a specific protecting group; and the lines independently designate a bridging group  
 15 of the Formula: (i) -X-M-Y-W-Z- ; or (ii) -X-M-Z- wherein: one line may be absent; M and W are independently selected from the group consisting of disulfide, amide, thioether, thioesters, imines, ethers and alkenes; and X, Y and Z are each independently selected from the group  
 20 consisting of alkylene, substituted alkylene, arylene, homo- or hetero-cycloalkylene and substituted cycloalkylene.

In certain preferred embodiments, the CO-E group of Formula (I) is reduced to a CH<sub>2</sub>OH group.

Another embodiment of the present invention involves N-  
 25 backbone to side chain cyclized peptides of the general formula (II):



## Formula (II)

wherein the substituents are as defined above.

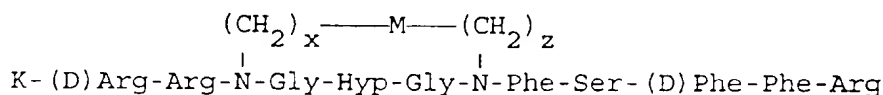
A preferred embodiment of the present invention involves the backbone cyclized peptide analog of Formulae I or II

wherein the amino acid residues are independently selected from the group consisting of disulfide, amide,

thioether, thioesters, imines, ethers and alkenes; x and z each independently designates an integer from 1 to 10, and y is zero or an integer of from 1 to 8, with the proviso that if y is zero, W is absent.

- 5 Further preferred are backbone cyclized peptide analogs of the Formula I or II wherein R and R' are other than H, such as CH<sub>3</sub>, (CH<sub>3</sub>)<sub>2</sub>CH-, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>-, CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)-, CH<sub>3</sub>S(CH<sub>2</sub>)<sub>2</sub>-, HOCH<sub>2</sub>-, CH<sub>3</sub>CH(OH)-, HSCH<sub>2</sub>-, NH<sub>2</sub>C(=O)CH<sub>2</sub>-, NH<sub>2</sub>C(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>-, HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub> 10 NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, and methylimidazole.

A more preferred embodiment of the present invention is directed to backbone cyclization to stabilize the β-turn conformation of bradykinin analogs of the general Formula 15 (III):

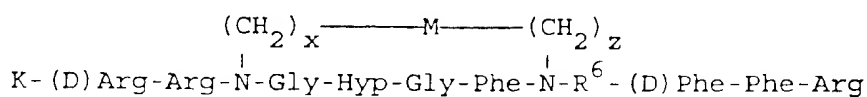


20

## Formula III

wherein M is an amide bond, x and z are each independently an integer of 1 to 10, and K is H or an acyl group.

- Also more preferred are backbone cyclized peptide analogs of the present invention comprising bradykinin analogs of the 25 general Formula (IVa):

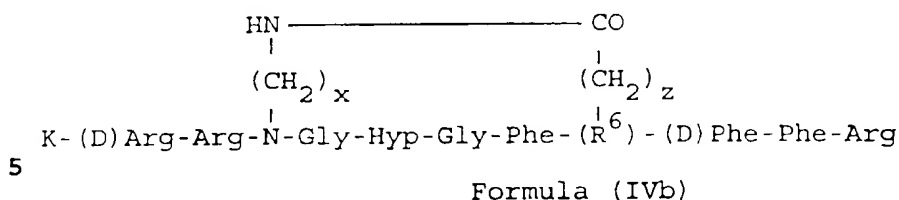


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## Formula (IVa)

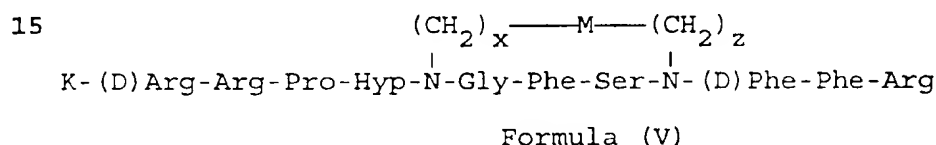
wherein M is an amide bond, x and z are each independently an integer of 1 to 10, K is H or an acyl group, and R<sup>6</sup> is Gly or Ser; or the general Formula (IVb):

35



wherein x is an integer of 1 to 10; K is H or an acyl group;  
 (R<sup>6</sup>) is selected from the group of D-Asp, L-Asp, D-Glu and  
 L-Glu; and z is according to the amino acid specified: 1 in  
 10 case of D and L-Asp, and 2 in the case of D and L Glu.

Further more preferred backbone cyclized peptide analogs  
 according to the present invention having bradykinin  
 antagonist activity have the Formula (V):



wherein M is an amide bond, x and z are each independently an  
 20 integer of 1 to 10, and K is H or an acyl group.

Specifically preferred backbone cyclized peptide analogs  
 of the present invention are:

- 1) Ada-(D)Arg-Arg-cyclo(N<sup>α</sup>(1-(6-aminohexylene)Gly-Hyp-Phe-D-  
 Asp)-D-Phe-Phe-Arg-OH;
- 25 2) H-D-Arg-Arg-cyclo(N<sup>α</sup>(1-(4-propanoyl))Gly-Hyp-Phe-N<sup>α</sup>(3-  
 amido-propylene)Gly)-Ser-D-Phe-Phe-Arg-OH; and
- 3) H-D-Arg-Arg-cyclo(N<sup>α</sup>(4-propanoyl)Gly-Hyp-Phe-N<sup>α</sup>(3-amido-  
 propyl)-S-Phe)-Ser-D-Phe-Phe-Arg-OH.

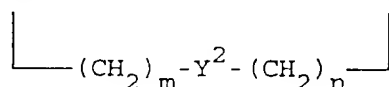
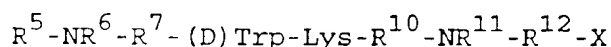
Another preferred aspect of the present invention is  
 30 directed to backbone cyclization to generate novel  
 somatostatin analogs linked between positions 6 and 11,  
 leaving the phenylalanine side chains untouched. This  
 conformational stabilization is much more rigid than the Phe<sup>6</sup>,  
 Phe<sup>11</sup> hydrophobic interaction in natural somatostatin and is

covalent bridge can be achieved while either one or both of the original Phe<sup>6</sup> and Phe<sup>11</sup> are retained.

Moreover, backbone cyclizations can also be used to anchor the  $\beta$ -turn, not only in positions 6 and 11 but also 5 inside the active reaction of Phe<sup>7</sup>-(D)Trp<sup>8</sup>-Lys<sup>9</sup>-Thr<sup>10</sup>, yielding either a monocyclic analog with a preferable conformation or a very rigid bicyclic analog. Here again, the side chains of the pharmacologically active amino acids remain untouched and the only change is in limiting the conformational space.

10 As used herein and in the claims in the following more preferred backbone cyclized peptide analogs, the superscript numbers following the amino acids refer to their position numbers in the native Somatostatin.

A more preferred backbone cyclized peptide novel analog 15 is the Formula (XIVa):



20

Formula (XIVa)

with a most preferred analog being the Formula (XIVb):

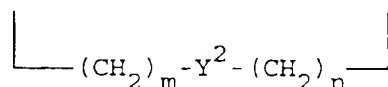
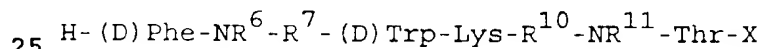
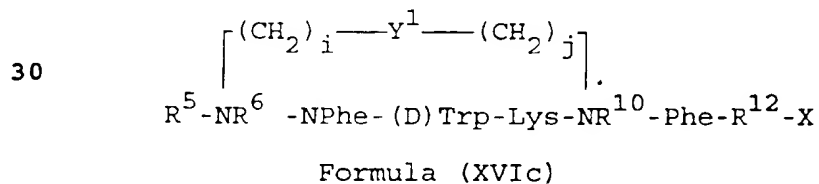
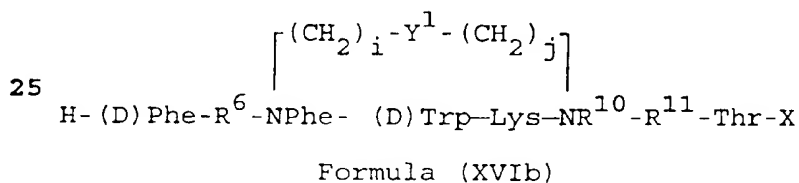
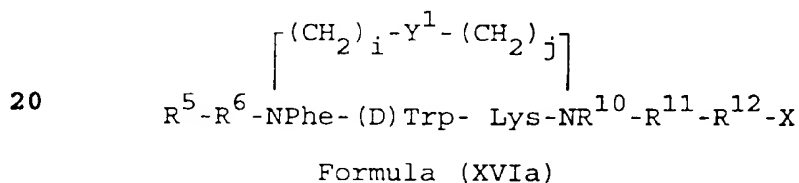
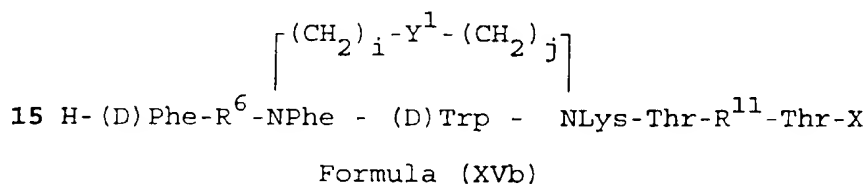
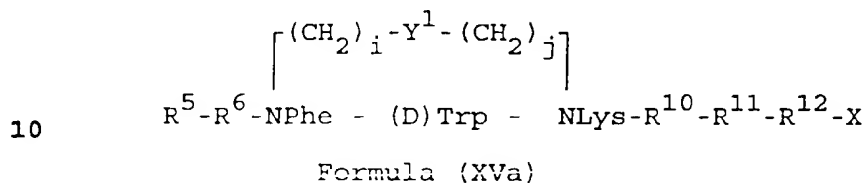


Figure (XIVb)

30 wherein m and n are 1, 2 or 3; X is CH<sub>2</sub>OH or CONH<sub>2</sub>; R<sup>5</sup> is absent or is Gly, (D)- or (L)-Ala, Phe, Nal and  $\beta$ -Asp(Ind); R<sup>6</sup> and R<sup>11</sup> are independently Gly or (D)- or (L)-Phe; R<sup>7</sup> is Phe or Tyr; R<sup>10</sup> is absent or is Gly, Abu, Thr or Val; R<sup>12</sup> is absent or is Thr or Nal, and Y<sup>2</sup> is selected from the group consisting of

phenylalanine side chains as in the natural somatostatin.  
Still more preferred is the analog wherein Phe<sup>7</sup> is replaced  
with Tyr<sup>7</sup> and Thr<sup>10</sup> is replaced with Val<sup>10</sup>.

Other more preferred monocyclic analogs that anchor the  
5 molecule in positions inside the active region rather than in  
positions 6 and 11 are formulae XV (a and b) and XVI (a-c):

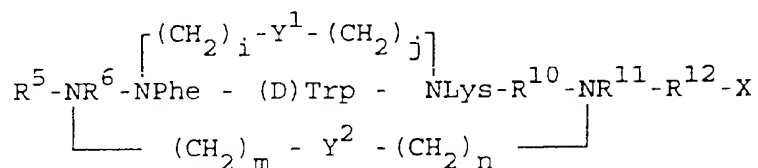


wherein  $i$  and  $j$  are independently 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100.

is (D)- or (L)-Phe;  $R^{12}$  is absent or is Thr or Nal, and  $Y^1$  is selected from the group consisting of amide, disulfide, thioether, imines, ethers and alkenes.

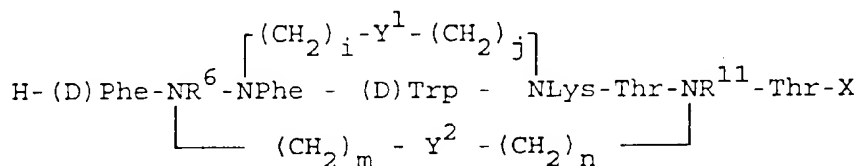
Still other more preferred analogs incorporate backbone cyclization in positions 6 and 11 as in Formula XIV, together with the backbone cyclizations as in Formula XV and XVI, yielding rigid bicyclic analogs of the Formulae XVII (a and b) and XVIII (a and b):

10



Formula (XVIIa)

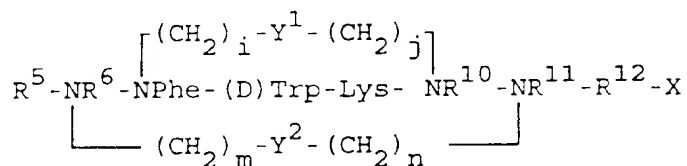
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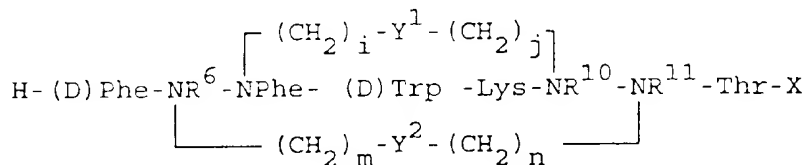
Formula (XVIIb)

25



Formula (XVIIIa)

30

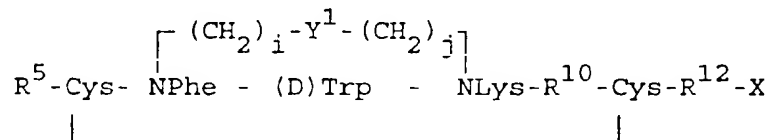


Formula (XVIIIb)

$R^{10}$  is absent or is Gly, Abu, Val or Thr;  $R^{12}$  is absent or is Thr or Nal; and  $Y^1$  and  $Y^2$  are independently selected from the group consisting of amide, disulfide, thioether, imines, ethers and alkenes.

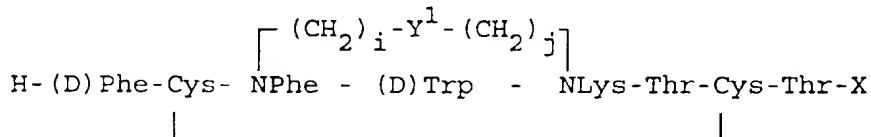
- 5 Other more preferred bicyclic analogs differ from Formulae XVII and XVIII by the replacement of the amino acids at positions 6 and 11 by cysteines which form a disulfide bond, leaving only one backbone cyclization in the Formulae XIX (a and b) and XX (a and b):

10



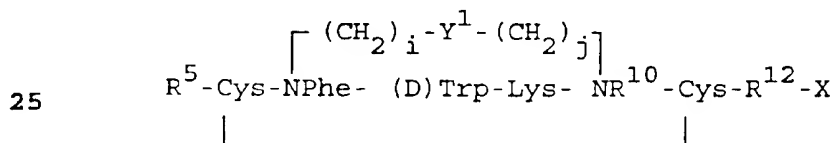
15

Formula (XIXa),



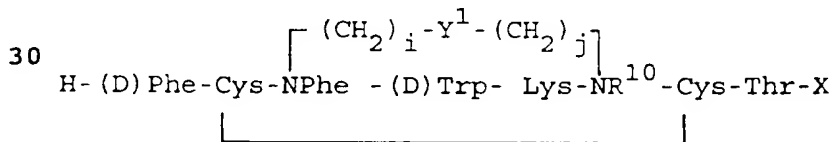
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Formula (XIXb),



25

Formula (XXa), and

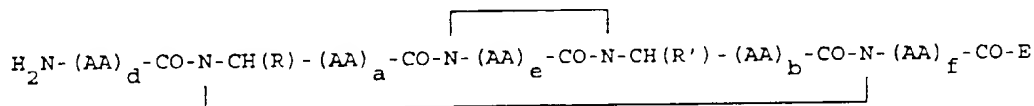


30

Formula (XXb)

Asp(Ind);  $R^6$  and  $R^{11}$  are independently Gly or Phe;  $R^{10}$  is absent or is Gly, Abu or Thr;  $R^{12}$  is absent or is Thr or Nal; and  $Y^1$  is selected from the group consisting of amide, disulfide, thioether, imines, ethers and alkenes.

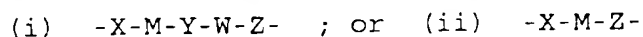
- 5 Another aspect of the present invention is a method for the preparation of cyclic peptides of the general Formula (I):



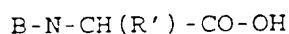
10

Formula (I)

- wherein: a and b each independently designates an integer from 1 to 8 or zero; d, e, and f each independently designates  
 15 an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same or different; E represents a hydroxyl group, a carboxyl protecting group or an amino group, or CO-E can be reduced to  $\text{CH}_2\text{-OH}$ ; R and R' each designates an amino acid side-chain  
 20 optionally bound with a specific protecting group; and the lines designate a bridging group of the Formula:



- wherein: one line may be absent; M and W are independently selected from the group consisting of disulfide,  
 25 amide, thioether, thioesters, imines, ethers and alkenes; and X, Y and Z are each independently selected from the group consisting of alkylene, substituted alkylene, arylene, homo- or hetero-cycloalkylene and substituted cycloalkylene. This method comprises the steps of incorporating at least one  $\text{N}^\alpha$ - $\omega$ -  
 30 functionalized derivative of amino acids of Formula (VI):



$$\downarrow$$

$$\text{X}$$

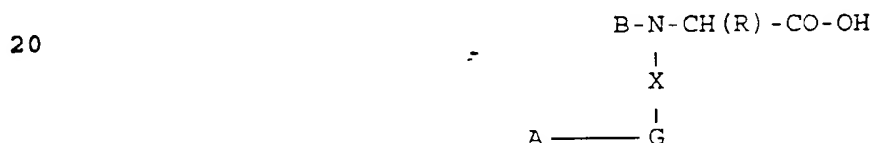
$$\downarrow$$

$$\text{C}$$



wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R' is an amino acid side chain, optionally bound with a specific protecting group; B is a  
 5 protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryl carbonyls; and G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters, aldehydes, alcohols and alkyl halides; and A is a specific protecting  
 10 group of G; into a peptide sequence and subsequently selectively cyclizing the functional group with one of the side chains of the amino acids in said peptide sequence or with another  $\omega$ -functionalized amino acid derivative.

A further object of the present invention is directed to  
 15 building units known as a  $N^{\omega}$ - $\omega$ -functionalized derivatives of the general Formula (VI) of amino acids which are prerequisites for the cyclization process:



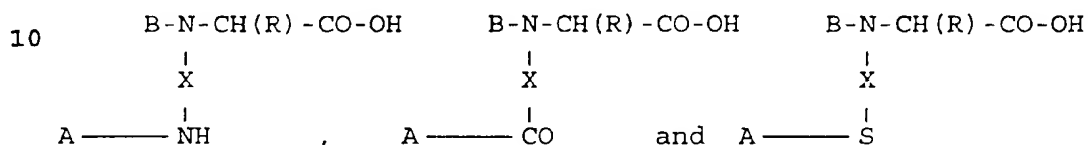
Formula (VI)

25 wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R is the side chain of an amino acid, optionally bound with a specific  
 30 protecting group; B is a protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; and G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters, aldehydes and alkyl halides; and A is a protecting

amine group or a carboxyl group; R is phenyl, methyl or isobutyl; with the proviso that when G is an amine group, R is other than H.

Further preferred are  $\omega$ -functionalized amino acid  
5 derivatives wherein R is protected with a specific protecting  
group.

More preferred are  $\omega$ -functionalized amino acid derivatives of the Formulae:



<sup>15</sup> wherein X, R, A and B are as defined above.

Specifically preferred  $\omega$ -functionalized amino acid derivatives include the following:

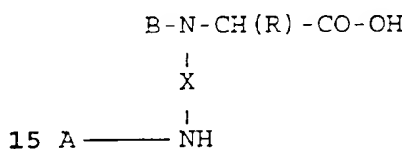
- 1) N<sup>α</sup>-(Fmoc) (3-Boc-amino propylene) - (S) Phenylalanine;
- 2) N<sup>α</sup>-(Fmoc) (3-Boc-amino propylene) - (R) Phenylalanine;
- 20 3) N<sup>α</sup>-(Fmoc) (4-Boc-amino butylene) - (S) Phenylalanine;
- 4) N<sup>α</sup>-(Fmoc) (3-Boc-amino propylene) - (S) Alanine;
- 5) N<sup>α</sup>-(Fmoc) (6-Boc-amino hexylene) - (S) Alanine;
- 6) N<sup>α</sup>-(Fmoc) (3-Boc-amino propylene) - (R) Alanine;
- 7) N<sup>α</sup>-(2-(benzylthio)ethylene)glycine ethyl ester;
- 25 8) N<sup>α</sup>-(2-(benzylthio)ethylene) (S) leucine methyl ester;
- 9) N<sup>α</sup>-(3-(benzylthio)propylene) (S) leucine methyl ester:
- 10) Boc-N<sup>α</sup>-(2-(benzylthio)ethylene)glycine;
- 11) Boc-N<sup>α</sup>-(2-(benzylthio)ethylene) (S) phenylalanine;
- 12) Boc-N<sup>α</sup>-(3-(benzylthio)propylene) (S) phenylalanine;
- 30 13) Boc-L-phenylalanyl-N<sup>α</sup>-(2-(benzylthio)ethylene)glycine-ethyl ester;
- 14) Boc-L-phenylalanyl-N<sup>α</sup>-(2-(benzylthio)ethylene) - (S) phenylalanine methyl ester;
- 15) N<sup>α</sup>(Fmoc) - (2-t-butyl carboxy ethylene)glycine;

- 18) N<sup>α</sup>(Fmoc)(2-Boc amino ethylene)glycine;  
 19) N<sup>α</sup>(Fmoc)(3-Boc amino propylene)glycine;  
 20) N<sup>α</sup>(Fmoc)(4-Boc amino butylene)glycine; and  
 21) N<sup>α</sup>(Fmoc)(6-Boc amino hexylene)glycine.

5

Novel, practical, generally applicable processes for the preparation of these N<sup>α</sup>-ω-functionalized derivatives of amino acids are a further aspect of this invention.

As such, an object of this invention is a method of making an ω-functionalized amino acid derivative of the general Formula:



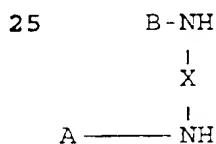
15

wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R is the side chain of an amino acid, such as H, CH<sub>3</sub>, etc.; A and B are protecting groups selected from the group consisting of alkyloxy, substituted alkyloxy, or aryloxy carbonyls;

20

comprising the steps of:

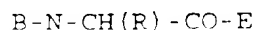
i) reacting a diamine compound of the general Formula:



25

wherein A, B and X are as defined above, with a triflate of Formula CF<sub>3</sub>SO<sub>2</sub>-O-CH(R)-CO-E wherein E is a carboxyl protecting group and R is as defined above; to yield a compound of Formula:

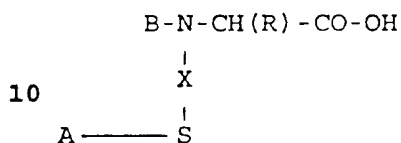
30



wherein A, B, E, R and X are as defined above

ii) and deprotecting the carboxyl to yield an N<sup>α</sup> ω-functionalized amino acid derivative, wherein the ω-functional group is an amine.

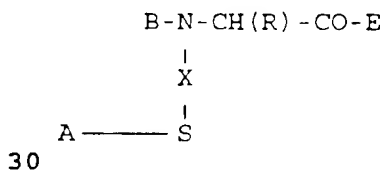
- 5 A further object of this invention is a method of making an ω-functionalized amino acid derivative of the general Formula:



where B is a protecting group selected from the group of substituted alkyloxy, substituted alkyloxy, or aryloxy  
 15 carbonyls; R is the side chain of an amino acid, such as H, CH<sub>3</sub>, etc.; X is a spacer group selected from the group of alkylene, substituted alkylene, arylene, cycloalkylene or substituted cycloalkylene; and A is a protecting group selected from the group of alkyl or substituted alkyl, thio  
 20 ethers or aryl or substituted aryl thio ethers;

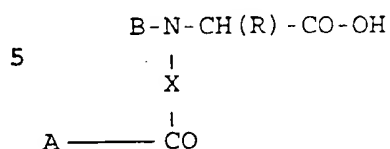
comprising the steps of:

- i) reacting a compound of the general Formula B-NH-X-S-A with a triflate of the general Formula CF<sub>3</sub>SO<sub>2</sub>-O-CH(R)-CO-E wherein E is a carboxyl protecting group and A, X and R are as  
 25 defined above, to give a compound of the Formula:



- ii) selectively removing the protecting group E, and  
 iii) protecting the free amino group to yield an N<sup>α</sup>(ω-functionalized) amino acid derivative, wherein the ω-

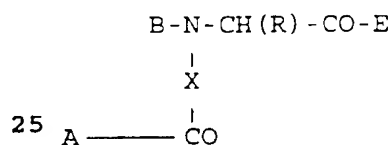
A further object of this invention is a method of making an  $\omega$ -functionalized amino acid derivative of the general Formula:



where B is a protecting group selected from the group of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; R is the side chain of an amino acid, such as H, CH<sub>3</sub>, etc.; X is a spacer group selected from the group of alkylene, substituted alkylene, arylene, cycloalkylene or substituted cycloalkylene; and A is a protecting group selected from the group of alkyl or substituted alkyl, esters, or thio esters or substituted aryl esters or thio esters;

comprising the steps of:

i) reacting a compound of the general Formula B-NH-X-CO-A with a triflate of the general Formula CF<sub>3</sub>SO<sub>2</sub>-O-CH(R)-CO-E wherein E is a carboxyl protecting group and A, B, X and R are as defined above, to give a compound of Formula:



ii) and selectively removing protecting group E, to yield an N $^{\omega}$ ( $\omega$ -functionalized) amino acid derivative, wherein the  $\omega$ -functional group is a carboxyl.

A further aspect of this invention is to provide methods for the preparation of novel backbone cyclic peptides, comprising the steps of incorporating at least one N $^{\omega}$ - $\omega$ -functionalized derivatives of amino acids into a peptide sequence and subsequently selectively cyclizing the peptide

derivative.

Backbone cyclized analogs of the present invention may be used as pharmaceutical compositions and for methods for the treatment of disorders including: acute asthma, septic shock, brain trauma and other traumatic injury, post-surgical pain, 5 all types of inflammation, cancers, endocrine disorders and gastrointestinal disorders.

Therefore, further objects of the present invention are directed to pharmaceutical compositions comprising pharmacologically active backbone cyclized peptide agonists and antagonists prepared according to the methods disclosed herein and a pharmaceutically acceptable carrier or diluent; and methods for the treatment of inflammation, septic shock, cancer or endocrine disorders and gastrointestinal disorders therewith.

15

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph showing *in vitro* biostability of somatostatin and three analogs thereof in human serum. The graph depicts the percentage of undegraded molecules for each of the compounds initially and after various periods of time.

## DETAILED DESCRIPTION OF THE INVENTION

## 25 Definitions

All abbreviations used are in accordance with the IUPAC-IUB recommendations on Biochemical Nomenclature (J. Biol. Chem., 247:977-983, 1972) and later supplements.

As used herein and in the claims, the phrase "an amino  
30 acid side chain" refers to the distinguishing substituent  
attached to the  $\alpha$ -carbon of an amino acid; such distinguishing  
groups are well known to those skilled in the art. For  
instance, for the amino acid glycine, the R group is H; for  
the amino acid alanine, R is  $\text{CH}_3$ , and so on. Other amino acids



HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub> NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, and methylimidazole.

As used herein and in the claims, the letters "(AA)" and the term "amino acid" are intended to include common natural or synthetic amino acids, and common derivatives thereof, known to those skilled in the art, including but not limited to the following. Typical amino-acid symbols denote the L configuration unless otherwise indicated by D appearing before the symbol.

10

	<u>Abbreviated Designation</u>	<u>Amino Acids</u>
	Abu	$\alpha$ -Amino butyric acid
	Ala	L-Alanine
	Arg	L-Arginine
	Asn	L-Asparagine
	Asp	L-Aspartic acid
15	$\beta$ Asp(Ind)	$\beta$ -Indolinylnyl aspartic acid
	Cys	L-Cysteine
	Glu	L-Glutamic acid
	Gln	L-Glutamine
	Gly	Glycine
	His	L-Histidine
	Hyp	trans-4-L-Hydroxy Proline
	Ile	L-Isoleucine
20	Leu	L-Leucine
	Lys	L-Lysine
	Met	L-Methionine
	Nal	$\beta$ -Naphthyl alanine
	Orn	Ornithine
	Phe	L-Phenylalanine
	Pro	L-Proline
25	Ser	L-Serine
	Thr	L-Threonine
	Trp	L-Tryptophane
	Tyr	L-Tyrosine
	Val	L-Valine

30 Typical protecting groups, coupling agents, reagents and solvents such as but not limited to those listed below have the following abbreviations as used herein and in the claims. One skill in the art would understand that the compounds listed within each group may be used interchangeably for

including, but not limited to, other possible protecting groups,

coupling agents and reagents/solvents; these are intended to be within the scope of this invention.

	<u>Abbreviated Designation</u>	<u>Protecting Groups</u>
5	Ada	Adamantane acetyl
	Alloc	Allyloxycarbonyl
	Allyl	Allyl ester
	Boc	tert-butyloxycarbonyl
	Bzl	Benzyl
	Fmoc	Fluorenylmethyloxycarbonyl
	OBzl	Benzyl ester
	OEt	Ethyl ester
	OMe	Methyl ester
	Tos (Tosyl)	p-Toluenesulfonyl
10	Trt	Triphenylmethyl
	Z	Benzyloxycarbonyl
	<u>Abbreviated Designation</u>	<u>Coupling Agents</u>
15	BOP	Benzotriazol-1-yloxytris-(dimethyl-amino)phosphonium hexafluorophosphate
	DIC	Diisopropylcarbodiimide
	HBTU	2-(1H-Benzotriazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate
20	PyBrOP	Bromotripyrrolidinophosphonium hexafluorophosphate
	PyBOP	Benzotriazol-1-yl-oxy-tris-pyrrolidino-phosphonium hexafluorophosphate
25	TBTU	O-(1,2-dihydro-2-oxo-1-pyridyl)-N,N,N',N'-tetramethyluronium tetrafluoroborate
	<u>Abbreviated Designation</u>	<u>Reagents and Solvents</u>
30	ACN	Acetonitrile
	AcOH	Acetic acid
	Ac <sub>2</sub> O	Acetic acid anhydride
	AdacOH	Adamantane acetic acid
	Alloc-Cl	Allyloxycarbonyl chloride
	Et <sub>3</sub> N	Triethylamine



	EtOAc	Ethyl acetate
	FmocOSu	9-fluorenylmethyloxy carbonyl N-hydroxysuccinimide ester
	HOBT	1-Hydroxybenzotriazole
	HF	Hydrofluoric acid
	MeOH	Methanol
5	Mes (Mesyl)	Methanesulfonyl
	NMP	1-methyl-2-pyrrolidinone
	nin.	Ninhydrin
	i-PrOH	Iso-propanol
	Pip	Piperidine
	PP	4-pyrrolidinopyridine
	Pyr	Pyridine
10	SRIF	Somatotropin release inhibiting factor
	SST	Somatostatin
	SSTR	Somatostatin receptor
	TEA	Triethylamine
	TFA	Trifluoroacetic acid
	THF	Tetrahydrofuran
	Triflate (Trf)	Trifluoromethanesulfonyl
15	Trf <sub>2</sub> O	Trifluoromethanesulfonic acid anhydride

The compounds herein described may have asymmetric centers. All chiral, diastereomeric, and racemic forms are included in the present invention. Many geometric isomers of olefins and the like can also be present in the compounds described herein, and all such stable isomers are contemplated in the present invention.

By "stable compound" or "stable structure" is meant herein a compound that is sufficiently robust to survive isolation to a useful degree of purity from a reaction mixture, and Formulation into an efficacious therapeutic agent.

As used herein and in the claims, "alkyl" or "alkylenyl" is intended to include both branched and straight-chain saturated aliphatic hydrocarbon groups having the C1 to C10 carbon atoms; "alkenyl" is intended to include hydrocarbon chains of either a straight or branched configuration and one or more unsaturated carbon-carbon bonds which may occur in any stable point along the chain such as ethenyl, propenyl, and

or more triple carbon-carbon bonds which may occur in any stable point along the chain, such as ethynyl, propynyl, and the like.

As used herein and in the claims, "aryl" is intended to mean any stable 5- to 7-membered monocyclic or bicyclic or 7- to 14-membered bicyclic or tricyclic carbon ring, any of which may be saturated, partially unsaturated or aromatic, for example, phenyl, naphthyl, indanyl, or tetrahydronaphthyl tetralin, etc.

10 As used herein and in the claims, "alkyl halide" is intended to include both branched and straight chain saturated aliphatic hydrocarbon groups having the C1 to C10 carbon atoms, wherein 1 to 3 hydrogen atoms have been replaced by a halogen atom such as Cl, F, Br, and I.

15 As used herein and in the claims, the term "heterocyclic" is intended to mean any stable 5- to 7- membered monocyclic or bicyclic or 7- to 10- membered bicyclic heterocyclic ring, which is either saturated or unsaturated, and which consists of carbon atoms and from 1 to 3 heteroatoms selected from the  
20 group consisting of N, O, and S and wherein the nitrogen and sulfur atoms may optionally be oxidized, and the nitrogen atom optionally be quaternized, and including any bicyclic group in which any of the above-defined heterocyclic rings is fused to a benzene ring. The heterocyclic ring may be attached to its  
25 pendant group at any heteroatom or carbon atom which results in a stable structure. The heterocyclic rings described herein may be substituted on carbon or on a nitrogen atom if the resulting compound is stable. Examples of such heterocycles include, but are not limited to pyridyl,  
30 pyrimidinyl, furanyl, thienyl, pyrrolyl, pyrazolyl, imidazolyl, tetrazolyl, benzofuranyl, benzothiophenyl, indolyl, indolenyl, quinolinyl, piperidonyl, pyrrolidinyl, pyrrolinyl, tetrahydrofuranyl, tetrahydroquinolinyl, tetrahydroisoquinolinyl, decahydroquinolinyl, or

It is to be understood that the above description is intended to illustrate the invention and is not to be construed as limiting the scope of the invention.

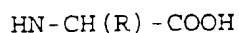
backbone cyclized peptide analog or composition comprising same to administer to a host to achieve the desired results for the indications described herein, such as but not limited of inflammation, septic shock, cancer, endocrine disorders and  
5 gastrointestinal disorders.

The term, "substituted" as used herein and in the claims, means that any one or more hydrogen atoms on the designated atom is replaced with a selection from the indicated group, provided that the designated atom's normal valency is not  
10 exceeded, and that the substitution results in a stable compound.

When any variable (for example R, x, z, etc.) occurs more than one time in any constituent or in Formulae (I to XX) or any other Formula herein, its definition on each occurrence is  
15 independent of its definition at every other occurrence. Also, combinations of substituents and/or variables are permissible only if such combinations result in stable compounds.

## 20 Synthetic Approach

According to the present invention peptide analogs are cyclized via bridging groups attached to the alpha nitrogens of amino acids that permit novel non-peptidic linkages. In general, the procedures utilized to construct such peptide  
25 analogs from their building units rely on the known principles of peptide synthesis; most conveniently, the procedures can be performed according to the known principles of solid phase peptide synthesis. The innovation requires replacement of one or more of the amino acids in a peptide sequence by novel  
30 building units of the general Formula:



cyclization will be effected. The side chain R is the side chain of any natural or synthetic amino acid that is selected to be incorporated into the peptide sequence of choice. X is a spacer group that is selected to provide a greater or lesser degree of flexibility in order to achieve the appropriate conformational constraints of the peptide analog. Such spacer groups include alkylene chains, substituted, branched and unsaturated alkylenes, arylenes, cycloalkylenes, unsaturated and substituted cycloalkylenes. Furthermore, X and R can be combined to form a heterocyclic structure.

A preferred embodiment of the present invention utilizes alkylene chains containing from two to ten carbon atoms.

The terminal ( $\omega$ ) functional groups to be used for cyclization of the peptide analog include but are not limited to:

- a. Amines, for reaction with electrophiles such as activated carboxyl groups, aldehydes and ketones (with or without subsequent reduction), and alkyl or substituted alkyl halides.
- b. Alcohols, for reaction with electrophiles such as activated carboxyl groups.
- c. Thiols, for the formation of disulfide bonds and reaction with electrophiles such as activated carboxyl groups, and alkyl or substituted alkyl halides.
- d. 1,2 and 1,3 Diols, for the formation of acetals and ketals.
- e. Alkynes or Substituted Alkynes, for reaction with nucleophiles such as amines, thiols or carbanions; free radicals; electrophiles such as aldehydes and ketones, and alkyl or substituted alkyl halides; or organometallic complexes.
- f. Carboxylic Acids and Esters, for reaction with nucleophiles (with or without prior activation), such as amines, alcohols, and thiols.
- g. Alkyl or Substituted Alkyl Halides, for reaction with nucleophiles such as amines, alcohols, thiols, carbanions, or free radicals.

or substituted alkyl halides, and formation of free radicals

for subsequent reaction with alkenes or substituted alkenes, and alkynes or substituted alkynes.

- h. Alkyl or Aryl Aldehydes and Ketones for reaction with nucleophiles such as amines (with or without subsequent  
5 reduction), carbanions (from active methylene groups such as acetoacetates or malonates), diols (for the formation of acetals and ketals).
- i. Alkenes or Substituted Alkenes, for reaction with nucleophiles such as amines, thiols, carbanions, free  
10 radicals, or organometallic complexes.
- j. Active Methylene Groups, such as malonate esters, acetoacetate esters, and others for reaction with electrophiles such as aldehydes and ketones, alkyl or substituted alkyl halides.

15

It will be appreciated that during synthesis of the peptide these reactive end groups, as well as any reactive side chains, must be protected by suitable protecting groups. Suitable protecting groups for amines are alkyloxy,  
20 substituted alkyloxy, and aryloxy carbonyls including, but not limited to, tert butyloxycarbonyl (Boc), Fluorenylmethyloxycarbonyl (Fmoc), Allyloxycarbonyl (Alloc) and Benzyloxycarbonyl (Z).

Carboxylic end groups for cyclizations may be protected  
25 as their alkyl or substituted alkyl esters or thio esters or aryl or substituted aryl esters or thio esters. Examples include but are not limited to tertiary butyl ester, allyl ester, benzyl ester, 2-(trimethylsilyl)ethyl ester and 9-methyl fluorenyl.

30 Thiol groups for cyclizations may be protected as their alkyl or substituted alkyl thio ethers or disulfides or aryl or substituted aryl thio ethers or disulfides. Examples of such groups include but are not limited to tertiary butyl, trityl(triphenylmethyl), benzyl, 2-(trimethylsilyl)ethyl

It will further be appreciated by the artisan that the various reactive moieties will be protected by different protecting groups to allow their selective removal. Thus, a particular amino acid will be coupled to its neighbor in the peptide sequence when the N<sup>α</sup> is protected by, for instance, protecting group A. If an amine is to be used as an end group for cyclization in the reaction scheme the N<sup>α</sup> will be protected by protecting group B, or an ε amino group of any lysine in the sequence will be protected by protecting group C, and so on.

The coupling of the amino acids to one another is performed as a series of reactions as is known in the art of peptide synthesis. Novel building units of the invention, namely the N<sup>α</sup>-ω functionalized amino acid derivatives are incorporated into the peptide sequence to replace one or more of the amino acids. If only one such N<sup>α</sup>-ω functionalized amino acid derivative is selected, it will be cyclized to a side chain of another amino acid in the sequence. For instance: (a) an N<sup>α</sup>-(ω-amino alkylene) amino acid can be linked to the carboxyl group of an aspartic or glutamic acid residue; (b) an N<sup>α</sup>-(ω-carboxylic alkylene) amino acid can be linked to the ε- amino group of a lysine residue; (c) an N<sup>α</sup>-(ω-thio alkylene) amino acid can be linked to the thiol group of a cysteine residue; and so on. A more preferred embodiment of the invention incorporates two such N<sup>α</sup>-ω-functionalized amino acid derivatives which may be linked to one another to form N-backbone to N-backbone cyclic peptide analogs. Three or more such building units can be incorporated into a peptide sequence to create bi-cyclic peptide analogs as will be elaborated below. Thus, peptide analogs can be constructed with two or more cyclizations, including N-backbone to N-backbone, as well as backbone to side-chain or any other peptide cyclization.

As stated above, the procedures utilized to synthesize

peptide analogs, it will be appreciated that accommodation



comprising the steps of incorporating at least one N<sup>α</sup>-ω-functionalized derivatives of amino acids of Formula (VI):



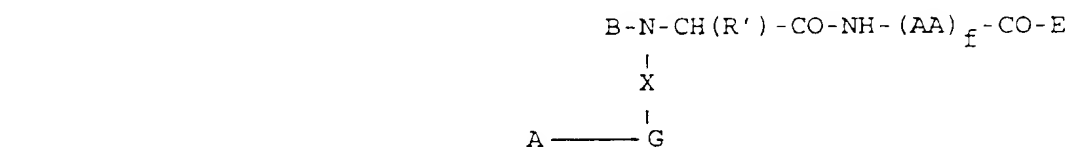
Formula (VI)

wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R' is an amino acid side chain such as H, CH<sub>3</sub>, etc., optionally bound with a specific protecting group; B is a protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; and G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters, aldehydes, alcohols and alkyl halides; and A is a specific protecting group of G;

with a compound of the Formula (VII):



wherein f is an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues may be the same or different, and E is a hydroxyl, a carboxyl protecting group or an amide to give a compound of the general Formula:

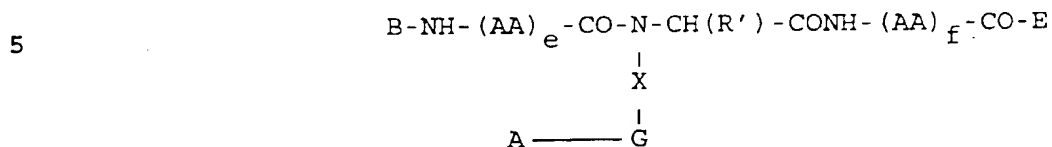


Formula (VIII)

(ii) selectively removing protecting group B and reacting the unprotected compound with a compound of Formula:



wherein B and (AA) are as described above and e is an integer from 1 to 10,  
to give a compound of Formula:



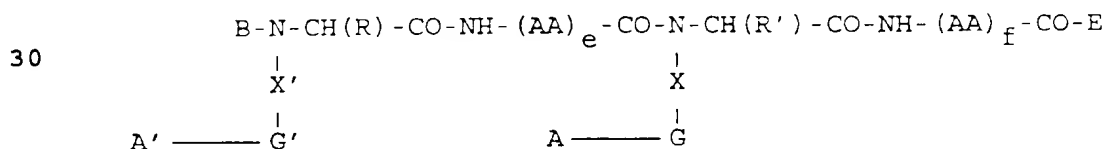
Formula (X)

10 wherein B, (AA), e, R<sup>1</sup>, and f are as described above;  
(iii) removing the protecting group B from the compound of the Formula (X) and reacting the unprotected compound with a compound of Formula:



Formula (VIa)

20 wherein X' is a spacer group selected from the group consisting of alkylenes, substituted alkylenes, arylenes, cycloalkylenes and substituted alkylenes; G' is a functional group selected from amines, thiols, carboxyls, aldehydes or alcohols; A' is a specific-protecting group thereof; R<sup>1</sup> is an amino acid side chain such as H, CH<sub>3</sub>, etc., optionally bound  
25 with a specific protecting group; and B is a protecting group;  
to yield a compound of Formula:

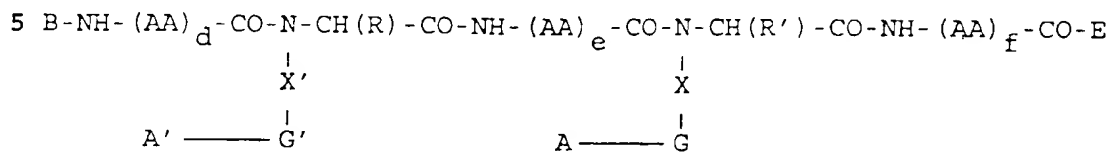


Formula (XI)

...-COOH

## Formula (IXa)

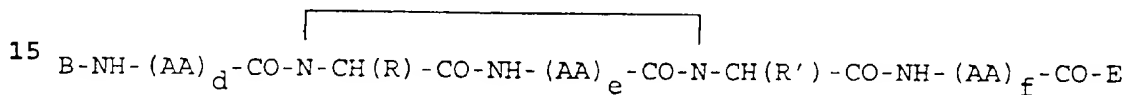
to yield a compound of Formula:



## Formula (XII)

10

(v) selectively removing protecting groups A and A' and reacting the terminal groups G and G' to form a compound of the Formula:



## Formula (XIII)

wherein d, e and f are independently an integer from 1 to 10; (AA) is an amino acid residue wherein the amino acid residues in each chain may be the same or different; E is an hydroxyl group, a carboxyl protecting group or an amino group; R and R' are independently an amino acid side-chain such as H, CH<sub>3</sub>, etc.; and the line designates a bridging group of the Formula: -X-M-Y-W-Z-

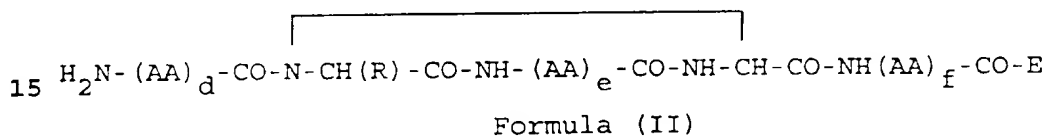
25 wherein M and W are independently selected from the group consisting of disulfide, amide, thioether, imine, ether, and alkene; X, Y and Z are independently selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene, and substituted cycloalkylene;

30 (vi) removing all remaining protecting groups to yield a compound of Formula (I).

Bicyclic analogs are prepared in the same manner, that is, by repetition of steps (v) and (vi). The determination of which residues are cyclized with which other residues is made

Preferred are methods for the preparation of backbone cyclized peptide analogs of Formula (I) wherein G is an amine, thiol or carboxyl group; R and R<sup>1</sup> are each other than H, such as CH<sub>3</sub>, (CH<sub>3</sub>)<sub>2</sub>CH-, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>-, CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)-, CH<sub>3</sub>S(CH<sub>2</sub>)<sub>2</sub>-,  
 5 HOCH<sub>2</sub>-, CH<sub>3</sub>CH(OH)-, HSCH<sub>2</sub>-, NH<sub>2</sub>C(=O)CH<sub>2</sub>-, NH<sub>2</sub>C(=O)(CH<sub>2</sub>)<sub>2</sub>-,  
 HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, and methylimidazole, and wherein E is covalently bound to an insoluble polymeric support.

10 Another object of the present invention is a method for the preparation of backbone cyclized peptide analogs of Formula (II):



wherein the substituents are as defined above;  
 comprising the steps of: incorporating at least one ω-  
 20 functionalized amino acid derivative of the general Formula (VI):



wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R is the side  
 30 chain of an amino acid, such as H, CH<sub>3</sub>, etc.; B is a protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; and G is a functional group selected from the group consisting of amine, thiol, carboxyl, and hydroxyl.

into a peptide sequence and subsequently selectively cyclizing the functional group with one of the side chains of the amino acids in said peptide sequence.

Preferred is the method for the preparation of backbone  
 5 cyclized peptide analogs of Formula (II) wherein G is a carboxyl group or a thiol group; R is  $\text{CH}_3$ ,  $(\text{CH}_3)_2\text{CH}-$ ,  $(\text{CH}_3)_2\text{CHCH}_2-$ ,  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)-$ ,  $\text{CH}_3\text{S}(\text{CH}_2)_2-$ ,  $\text{HOCH}_2-$ ,  $\text{CH}_3\text{CH}(\text{OH})-$ ,  $\text{HSCH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})\text{CH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{HOC}(=\text{O})\text{CH}_2-$ ,  $\text{HOC}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{NH}_2(\text{CH}_2)_4-$ ,  $\text{C}(\text{NH}_2)_2\text{NH}(\text{CH}_2)_3-$ , HO-phenyl- $\text{CH}_2-$ ,  
 10 benzyl, methylindole, and methylimidazole, and wherein E is covalently bound to an insoluble polymeric support.

Preparation of backbone to side chain cyclized peptide analogs is exemplified in Scheme I below. In this schematic  
 15 example, the bridging group consists of alkylene spacers and an amide bond formed between an acidic amino acid side chain (e.g. aspartic or glutamic acid) and an  $\omega$ -functionalized amino acid having a terminal amine.

## 20 (Scheme I)

### Preparation of peptides with Backbone to Side Chain cyclization.

One preferred procedure for preparing the desired backbone cyclic peptides involves the stepwise synthesis of  
 25 the linear peptides on a solid support and the backbone cyclization of the peptide either on the solid support or after removal from the support. The C-terminal amino acid is bound covalently to an insoluble polymeric support by a carboxylic acid ester or other linkages such as amides. An  
 30 example of such support is a polystyrene-co-divinyl benzene resin. The polymeric supports used are those compatible with such chemistries as Fmoc and Boc and include for example PAM resin, HMP resin and chloromethylated resin. The resin bound amino acid is deprotected for example with TBA to give (1)

The second amino acid is deprotected to give (3) using for

example piperidine 20% in DMF. The subsequent protected amino acids can then be coupled and deprotected at ambient temperature. After several cycles of coupling and deprotection that gives peptide (4), an amino acid having for  
5 example carboxy side chain is coupled to the desired peptide. One such amino acid is Fmoc-aspartic acid t-butyl ester. After deprotection of the N<sup>α</sup> Fmoc protecting group that gives peptide (5), the peptide is again elongated by methods well known in the art to give (6). After deprotection a building  
10 unit for backbone cyclization (the preparation of which is described in Schemes III-VIII) is coupled to the peptide resin using for example the coupling reagent BOP to give (7). One such building unit is for example Fmoc-N<sup>α</sup>(ω-Boc-amino alkylene)amino acid. After deprotection the peptide can then  
15 be elongated, to the desired length using methods well known in the art to give (8). The coupling of the protected amino acid subsequent to the building unit is performed by such coupling agents exemplified by PyBrOP<sup>®</sup> to ensure high yield.

After the linear, resin bound peptide, e.g. (8), has been  
20 prepared the ω-alkylene-protecting groups for example Boc and t-Bu are removed by mild acid such as TFA to give (9). The resin bound peptide is then divided into several parts. One part is subjected to on-resin cyclization using for example TBTU as cyclization agent in DMF to ensure high yield of  
25 cyclization, to give the N-backbone to side chain cyclic peptide resin (10). After cyclization on the resin the terminal amino protecting group is removed by agents such as piperidine and the backbone to side chain cyclic peptide (11) is obtained after treatment with strong acid such as HF.  
30 Alternatively, prior to the removal of the backbone cyclic peptide from the resin, the terminal amino group is blocked by acylation with agents such as acetic anhydride, benzoic anhydride or any other acid such as adamantyl carboxylic acid activated by coupling agents such as BOP

example the α-amino and carboxy groups. This is done by

reacting the  $\omega$ -amino group with for example  $\text{Ac}_2\text{O}$  and DMAP in DMF and activating the free  $\omega$ -carboxy group by for example DIC and HOBT to give the active ester which is then reacted with for example  $\text{Dh}_3\text{NH}_2$  to give the linear analog (13) of the  
5 cyclic peptide (10). Removal of the peptide from the resin and subsequent removal of the side chains protecting groups by strong acid such as HF to gives (14) which is the linear analog of the backbone to side chain cyclic peptide (11).

The linear analogs are used as reference compounds for  
10 the biological activity of their corresponding cyclic compounds.

[Reaction Scheme I follows at this point]

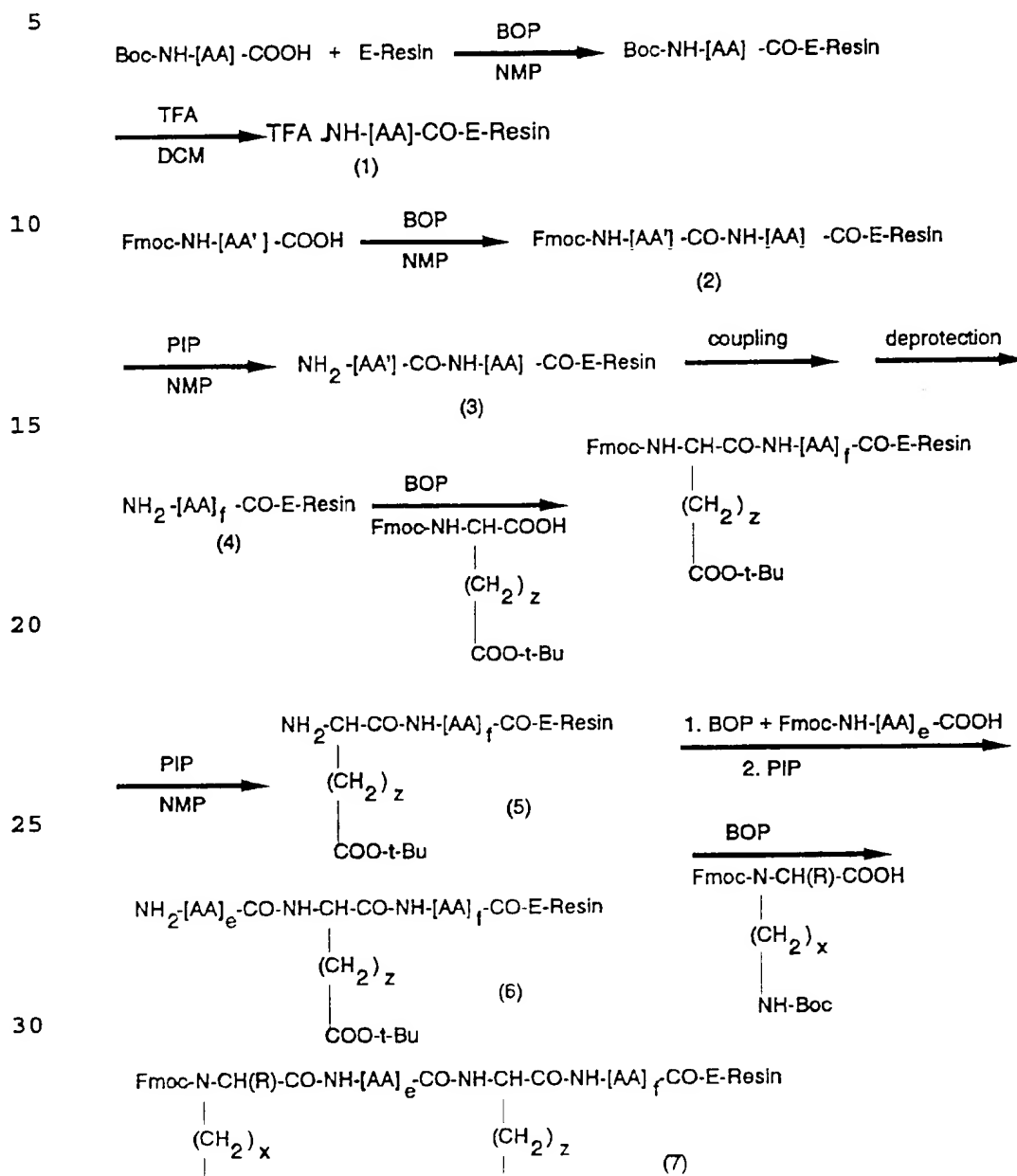
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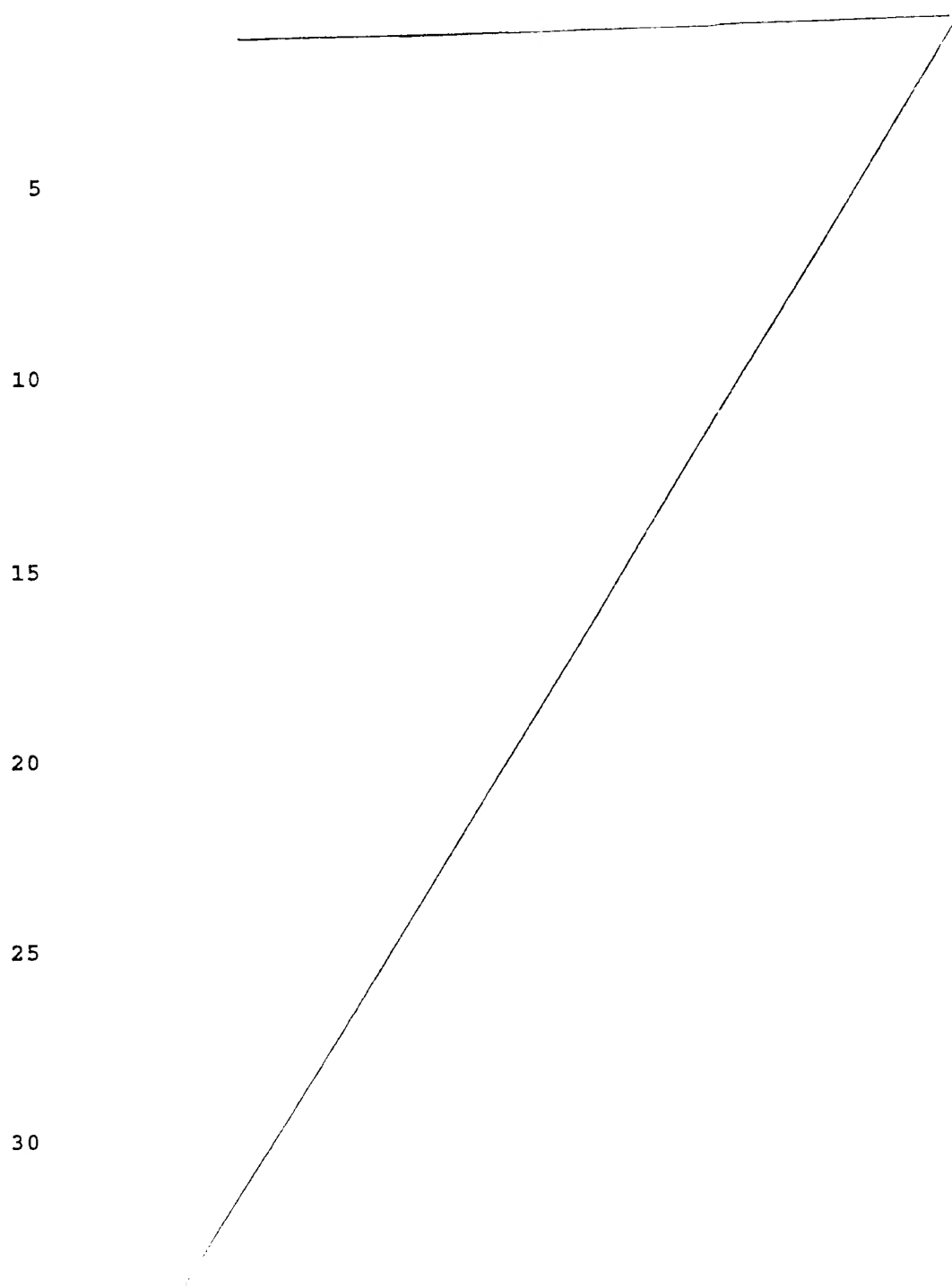
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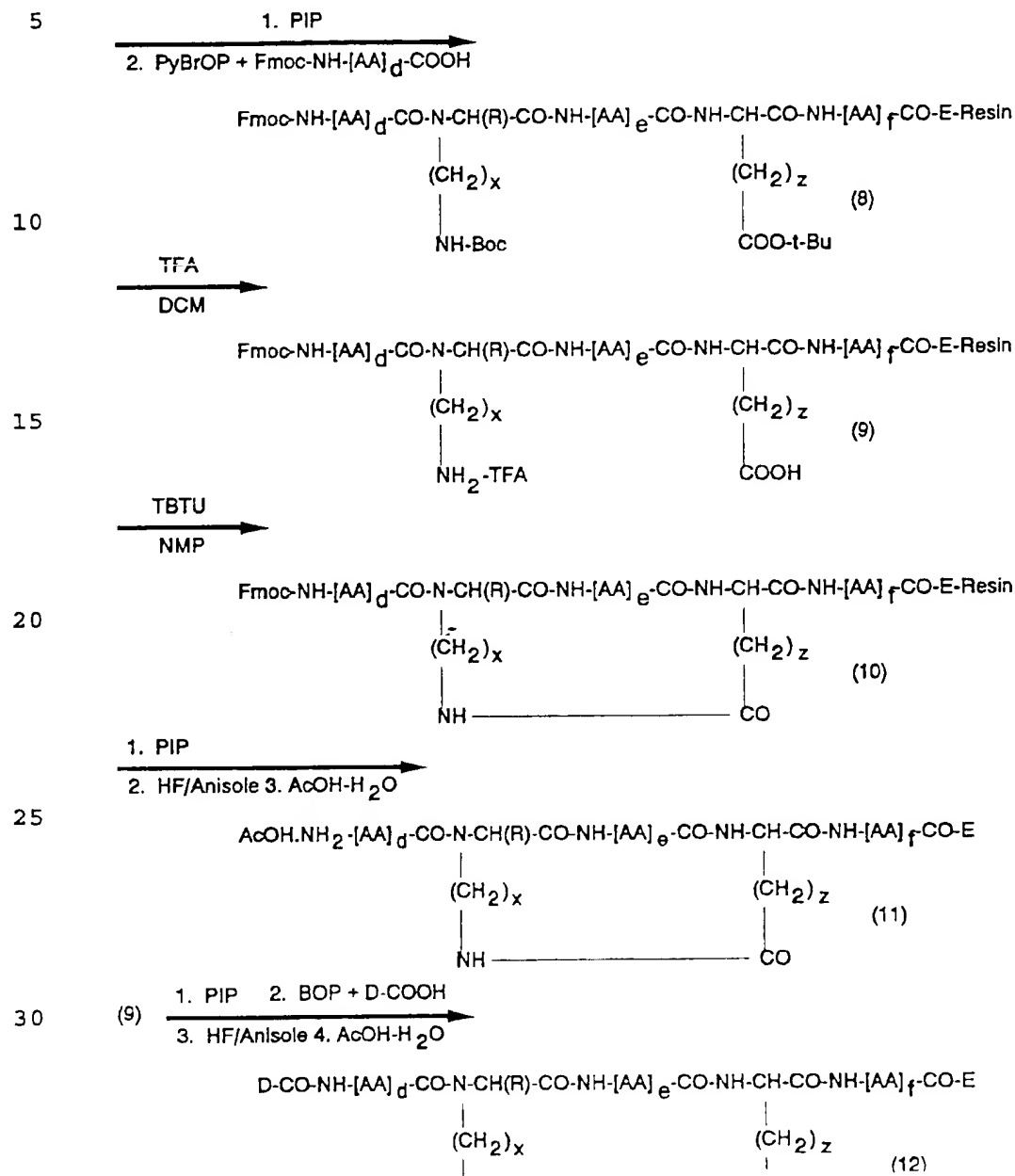
## SCHEME I







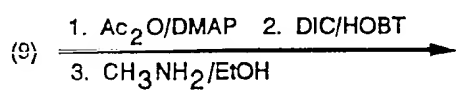
## SCHEME I (continued)



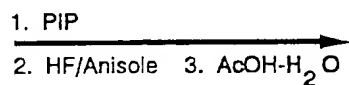
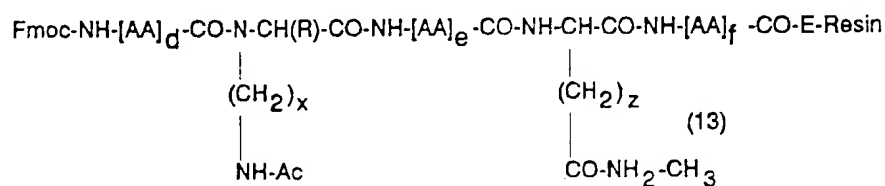
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## SCHEME I (continued)

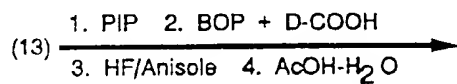
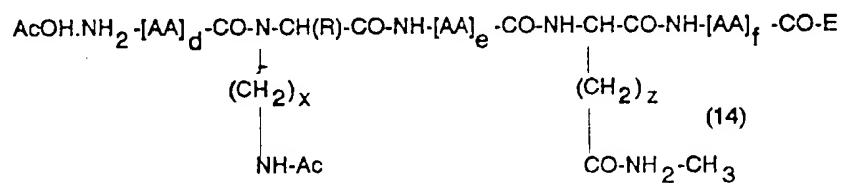
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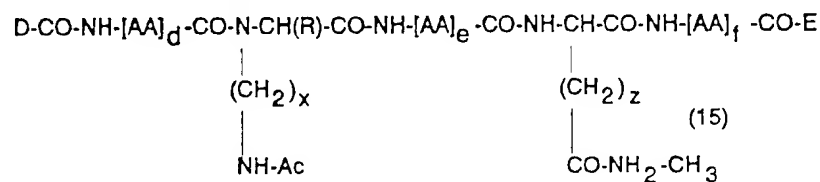
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The selection of N<sup>α</sup> and side chain protecting groups is, in part, dictated by the cyclization reaction which is done on the peptide-resin and by the procedure of removal of the peptide from the resin. The N<sup>α</sup> protecting groups are chosen in such a manner that their removal will not effect the removal of the protecting groups of the N<sup>α</sup>(ω-aminoalkylene) protecting groups. In addition, the removal of the N<sup>α</sup>(ω-aminoalkylene)protecting groups or any other protecting groups on ω-functional groups prior to the cyclization, will not effect the other side chain protection and/or the removal of the peptide from the resin. The selection of the side chain protecting groups other than those used for cyclization is chosen in such a manner that they can be removed subsequently with the removal of the peptide from the resin. Protecting groups ordinarily employed include those which are well known in the art, for example, urethane protecting substituents such as Fmoc, Boc, Alloc, Z and the like.

It is preferred to utilize Fmoc for protecting the  $\alpha$ -amino group of the amino acid undergoing the coupling reaction at the carboxyl end of said amino acid. The Fmoc protecting group is readily removed following such coupling reaction and prior to the subsequent step by the mild action of base such as piperidine in DMF. It is preferred to utilize Boc for protecting  $\omega$ -amino group of the N $^\omega$ ( $\omega$ -aminoalkylene) group and t-Bu for protecting the carboxy group of the amino acids undergoing the reaction of backbone cyclization. The Boc and t-Bu protecting groups are readily removed simultaneously prior to the cyclization.

## 30 (Scheme II)

### Preparation of peptides with Backbone to Backbone cyclization.

Preparation of N-backbone to N-backbone cyclized peptide analogs is exemplified in scheme II. In this schematic example, the building group consists of alkylene spacers and

peptide resin, for example peptide-resin (4), using for example the coupling reagent BOP to give (16). One such building unit is for example Fmoc-N $\alpha$ ( $\omega$ -Boc-amino alkylene)amino acid. The side chain Boc protecting group is removed by mild acid such as TFA in DCM and an N-Boc protected  $\omega$ -amino acid, or any other Boc protected amino acid, is coupled to the side chain amino group using coupling agent such as BOP to give peptide-resin (17).

After deprotection of the N $^{\alpha}$  Fmoc protecting group by mild base such as piperidine in DMF, the peptide can then be elongated, if required, to the desired length using methods well known in the art to give (18). Alternatively, the deprotection of the N $^{\alpha}$  Fmoc and subsequent elongation of the peptide can be done before deprotection of the side chain Boc protecting group. The elongation of the N-alkylene side chain allow control of the ring size. The coupling of the protected amino acid subsequent to the building unit is performed by such coupling agents exemplified by PyBrOP $^{\circ}$  to ensure high yield.

After deprotection of the terminal N $^{\alpha}$  Fmoc group, a second building unit, for example Fmoc-N $^{\alpha}$ ( $\omega$ -t-Bu-carboxy-alkylene)amino acid is coupled to the peptide-resin to give (19). After deprotection of the N $^{\alpha}$  Fmoc protecting group, the peptide can then be elongated, if required, to the desired length using methods well known in the art to give (20). The coupling of the protected amino acid subsequent to the building unit is performed by such coupling agents exemplified by PyBrOP $^{\circ}$  to ensure high yield. After the linear, resin bound peptide, e.g. (20), has been prepared the  $\omega$ -alkylene-protecting groups for example Boc and t-Bu are removed by mild acid such as TFA to give (21). The resin peptide is then divided into several parts. One part is subjected to on-resin cyclization using for example TBTU as cyclization agent in DMF to ensure high yield of cyclization to give the N $^{\alpha}$ -Boc-protected cyclic peptide.

After deprotection of the N $^{\alpha}$  Boc protecting group, the cyclic peptide is subjected to backbone cyclization to give the final cyclic peptide.

peptide (23) is obtained after treatment with strong acid such as HF. Alternatively, prior to the removal of the backbone cyclic peptide from the resin, the terminal amino group of (22) is blocked, after deprotection, by acylation with agents 5 such as acetic anhydride, benzoic anhydride or any other acid such as adamantyl carboxylic acid activated by coupling agents such as BOP to give the N-terminal blocked backbone to backbone cyclic peptide (24).

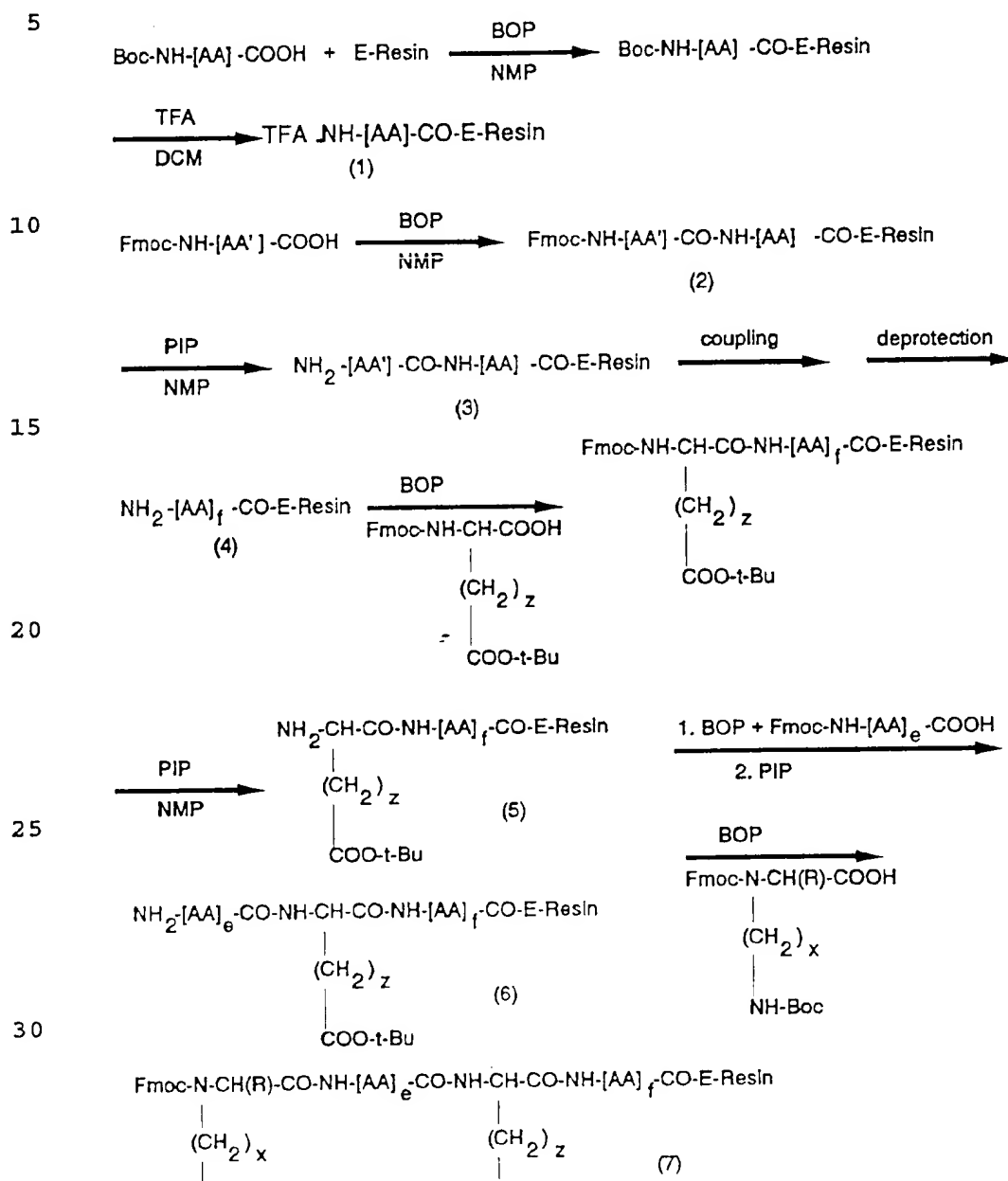
The other part of the peptide-resin (21) undergoes 10 protecting of the side chains used for cyclization, for example the  $\omega$ -amino and carboxy groups. This is done by reacting the  $\omega$ - amino group with for example  $\text{Ac}_2\text{O}$  and DMAP in DMF and activating the free  $\omega$ -carboxy group by for example DIC and HOBT to give the active ester which is then reacted with 15 for example  $\text{MeNH}_2$ . Removal of the peptide from the resin and subsequent removal of the side chains protecting groups by strong acid such as HF to gives (26) which is the linear analog of the backbone to backbone cyclic peptide (23). The linear analogs are used as reference compounds for the 20 biological activity of their corresponding cyclic compounds.

[Reaction Scheme II follows at this point]

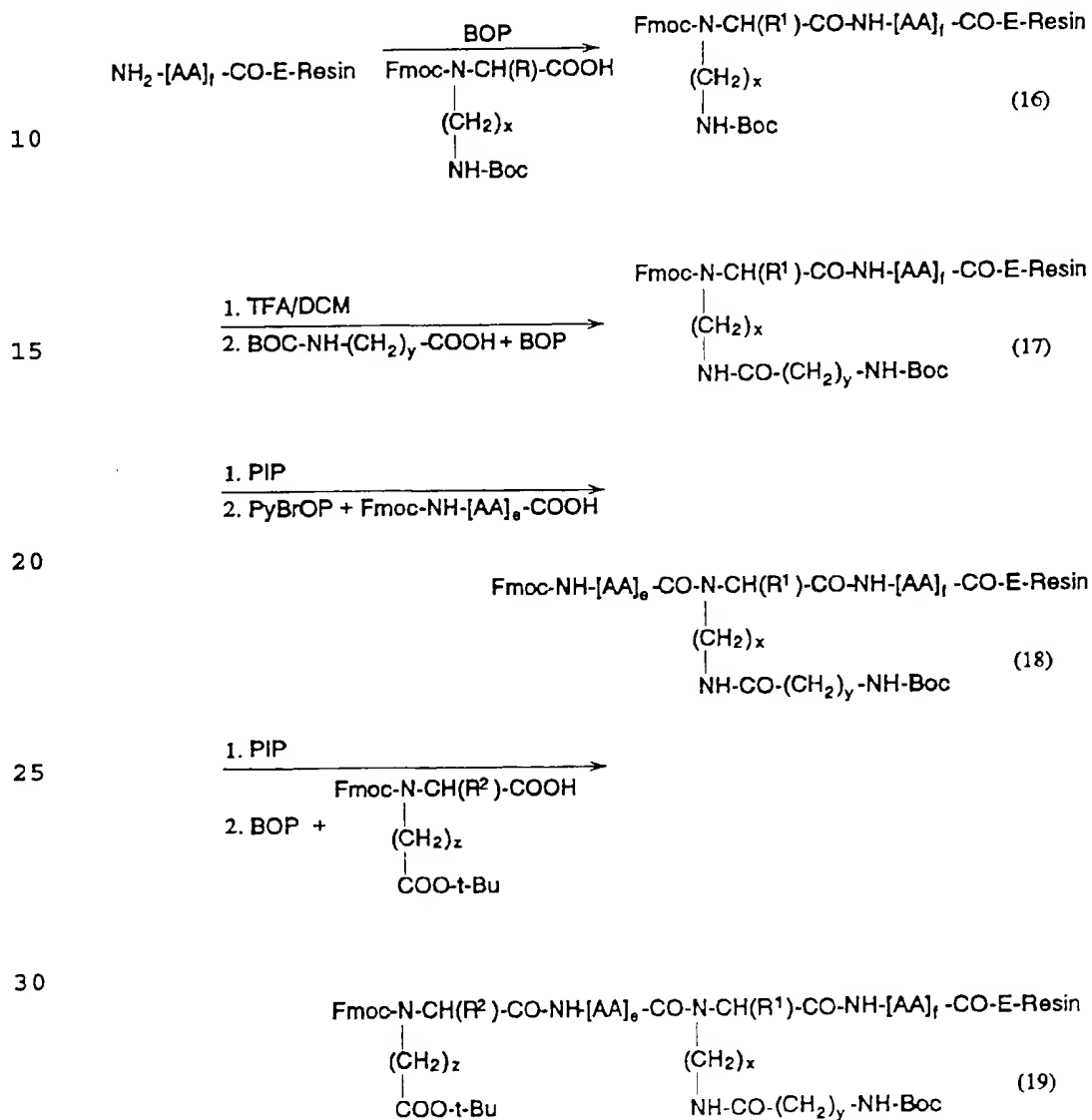
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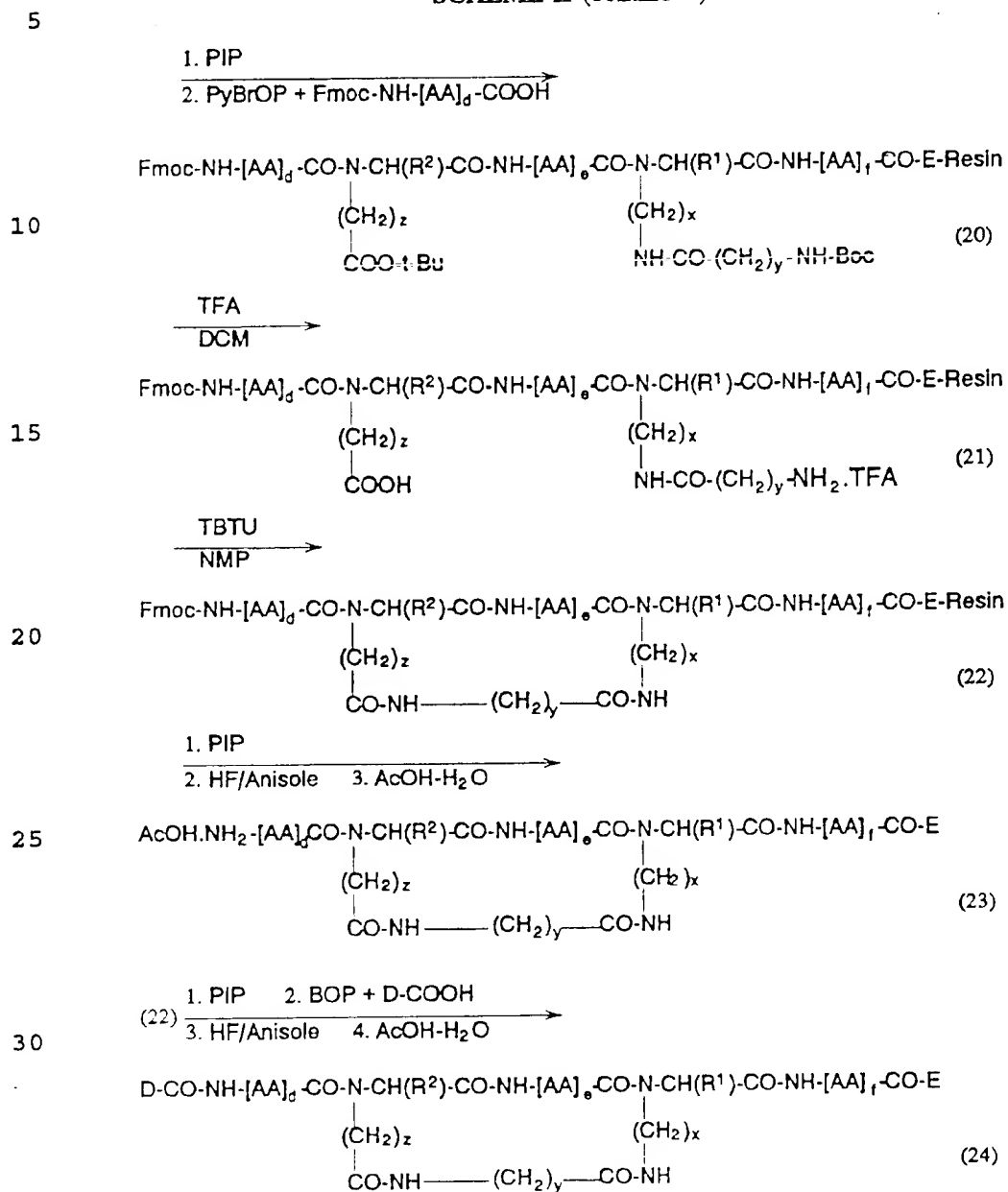
## SCHEME I



## SCHEME II



## SCHEME II (continued)

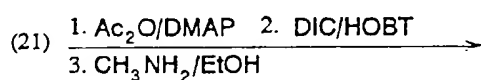




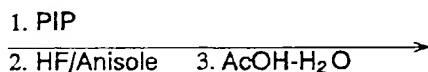
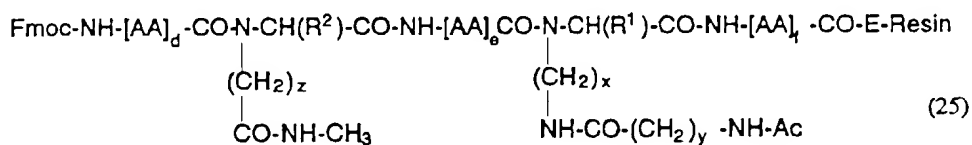
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## SCHEME II (continued)

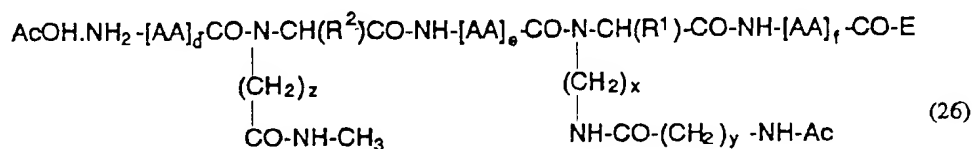
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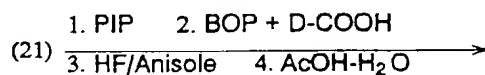
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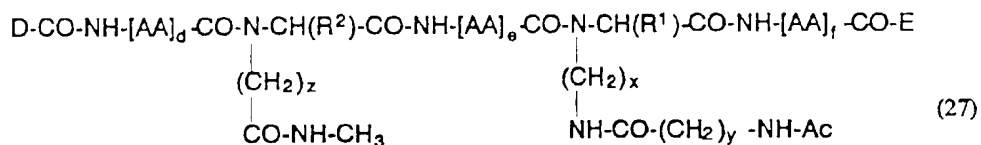
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### Novel Synthesis of Building Units

The novel synthesis providing N( $\omega$ -(functionalized) alkylene) amino acids used to generate backbone cyclic peptides is depicted in schemes III - VIII. In this approach  
5 we have implemented the following changes in order to devise a practical, general synthesis:

1. The nucleophile is a secondary nitrogen, which is a better nucleophile than the primary nitrogen previously used. This also prevents the possibility of double alkylation.
- 10 2. The leaving group was changed to trifluoromethanesulfonyl (triflate), which has a much lower tendency to eliminate than a halogen, thus making it possible to implement the synthesis with amino acids other than glycine. Furthermore, the triflate leaving group prevents racemization during the  
15 alkylation reaction.
3. The carboxylate is esterified prior to the substitution reaction, to facilitate the substitution by removing the negative charge next to the electrophilic carbon.

20

(Scheme III)

Preparation of N<sup>α</sup>, N<sup>ω</sup> protected  $\omega$ -amino alkylene amino acids building units.

One preferred procedure for the preparation of protected  
25 N<sup>α</sup>( $\omega$ - amino alkylene) amino acids involves the N<sup>α</sup> alkylation of suitably protected diamino alkanes. One preferred N<sup>α</sup>, N<sup>ω</sup> di- protected diamino alkane is for example N<sup>α</sup>-Benzyl, N<sup>ω</sup>-Boc diamino alkane (27). This starting material contains one protecting group such as Boc which is necessary for the final  
30 product, and a temporary protecting group such as Bzl to minimize unwanted side reactions during the preparation of the titled compound. One preferred procedure for the preparation of the starting material (27) involves reductive alkylation of N-Boc diamino alkane with aldehydes such as benzaldehyde.

the dialkylation side reaction and allows removal by such conditions that do not remove the N<sup>ω</sup>-protecting group.

The N<sup>α</sup>,N<sup>ω</sup> di-protected diamino alkane is reacted with for example chiral α-hydroxy α-substituted acid esters where the hydroxyl moiety is converted to a leaving group for example Triflate.

The use of Triflate as the leaving group was found to be superior to other leaving groups such as halogens, Tosyl, Mesyl, etc., because it prevents the β-elimination reaction encountered with the other leaving groups. The use of Triflate as the leaving group also ensures high optical purity of the product (28). The temporary N<sup>α</sup> protecting group, such as Bzl, and the carboxyl protecting group, such as methyl ester, are removed by mild conditions, such as catalytic hydrogenation and hydrolysis, that do not remove the N<sup>ω</sup> protecting group such as Boc to give the N<sup>ω</sup> protected amino acid (29). Introduction of the N<sup>α</sup> protecting group suitable for peptide synthesis is accomplished by methods well known in the art, to give the protected N<sup>α</sup>(N<sup>ω</sup> protected amino alkylene) amino acid (30).

The choice of the N<sup>α</sup> and the N<sup>ω</sup> protecting groups is dictated by the use of the building units in peptide synthesis. The protecting groups have to be orthogonal to each other and orthogonal to the other side chains protecting groups in the peptide. Combinations of N<sup>α</sup> and N<sup>ω</sup> protecting groups are for example: N<sup>α</sup>-Fmoc, N<sup>ω</sup>-Boc; N<sup>α</sup>-Fmoc, N<sup>ω</sup>-Alloc; N<sup>α</sup>-Boc, N<sup>ω</sup>-Alloc. These combinations are suitable for peptide synthesis and backbone cyclization, either on solid support or in solution.

30

#### (Scheme IV)

Preparation of N<sup>α</sup>, N<sup>ω</sup> protected ω-amino alkylene glycine building units.

N<sup>α</sup>, N<sup>ω</sup> di-protected α-amino alkane (27) with commercially

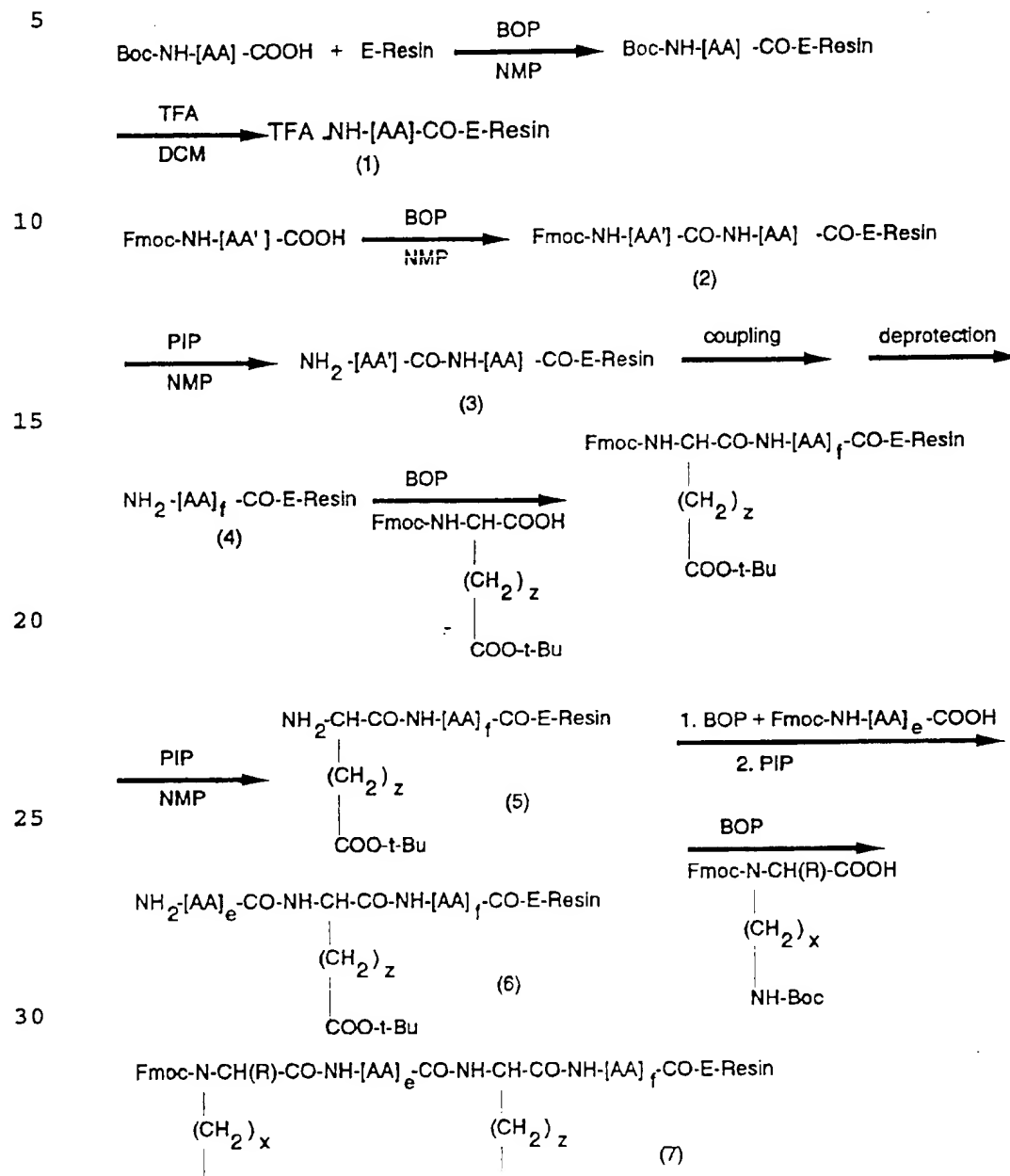
available  $\alpha$ -activated carboxylic acid esters, for example benzylbromo acetate. Since the titled compound is achiral, the use of leaving groups such as Trf, Tos or Mes is not necessary. The use of the same temporary protecting groups for the N $^{\alpha}$  and the carboxy groups, for example the Bzl protecting group, ensures the prevention of the undesired dialkylation side reaction and allows concomitant removal of the temporary protecting groups thus giving high yield of the N $^{\omega}$  protected amino acid (32). Introduction of the N $^{\alpha}$  protecting group suitable for peptide synthesis is accomplished by methods well known in the art, to give the protected N $^{\alpha}$  (N $^{\omega}$  protected amino alkylene) glycines (33).

The choice of the N $^{\alpha}$  and the N $^{\omega}$  protecting groups is dictated by the use of the building units in peptide synthesis. The protecting groups have to be orthogonal to each other and orthogonal to the other side chains protecting groups in the peptide. Combinations of N $^{\alpha}$  and N $^{\omega}$  protecting groups are for example: N $^{\alpha}$  Fmoc, N $^{\omega}$  Boc ; N $^{\alpha}$  Fmoc, N $^{\omega}$  Alloc; N $^{\alpha}$  Boc, N $^{\omega}$  Alloc. These combinations are suitable for peptide synthesis and backbone cyclization, either on solid support or in solution.

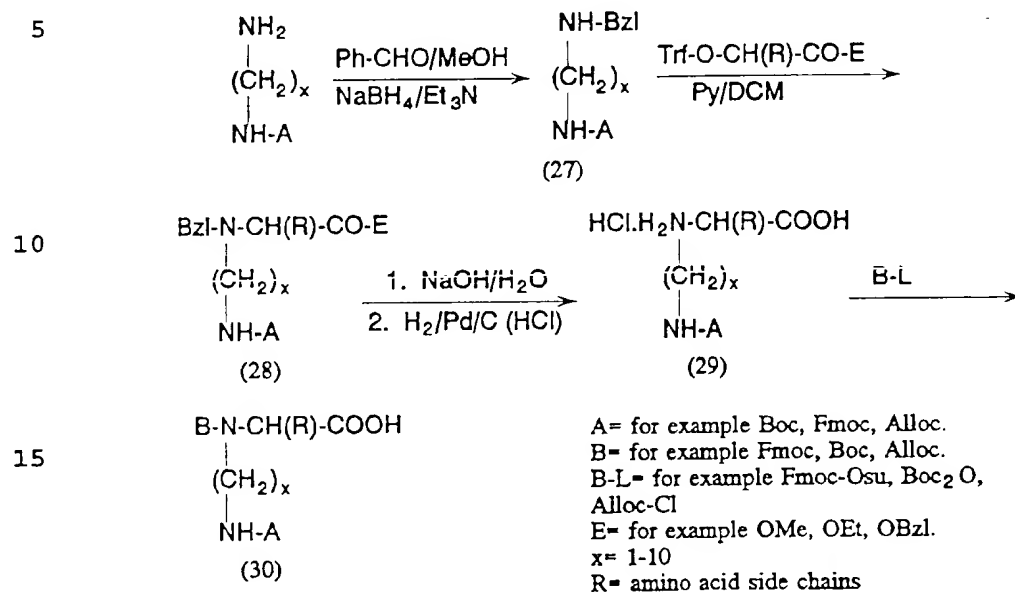
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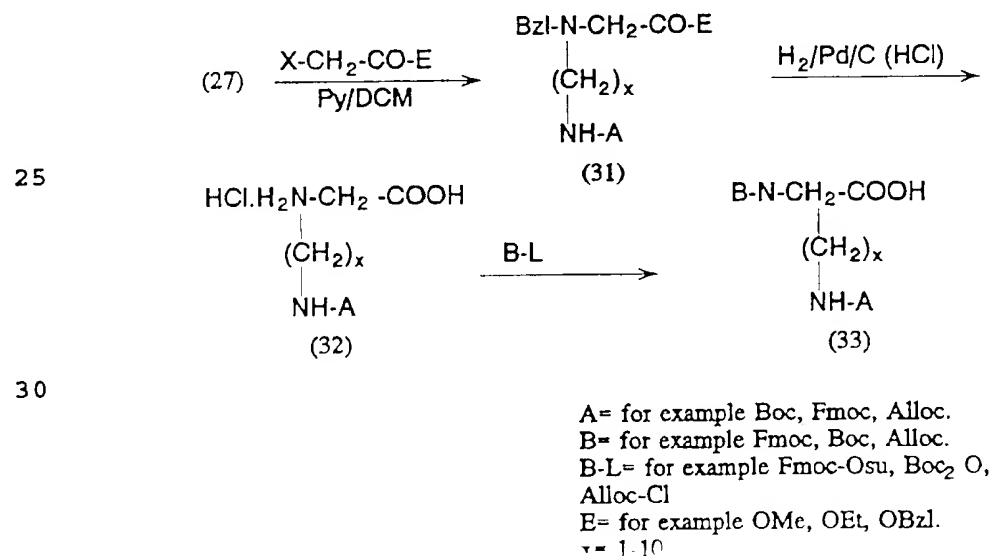
## SCHEME I



## SCHEME III



## SCHEME IV



(Scheme V)

Preparation of N<sup>α</sup>, ω-carboxy protected ω-carboxy alkylene amino acids.

One preferred procedure for the preparation of protected  
5 N<sup>α</sup>(ω-carboxy alkylene) amino acids involves the N<sup>α</sup>-alkylation  
of suitably N<sup>α</sup>, ω-carboxy deprotected amino acids. One  
preferred deprotected amino acid is N<sup>α</sup>-Benzyl ω-amino acids t-  
butyl esters (34). This starting material contains one  
10 protecting group such as t-Bu ester which is necessary for the  
final product, and a temporary protecting group such as N<sup>α</sup> Bzl  
to minimize side reactions during the preparation of the  
titled compound. One preferred procedure for the preparation  
of the starting material (34) involves reductive alkylation of  
ω-amino acids t-butyl esters with aldehydes such as  
15 benzaldehyde. The temporary protection of the amino group  
which is used as nucleophile in the proceeding alkylation  
reaction by such protecting groups as Bzl minimizes the  
dialkylation side reaction.

The N<sup>α</sup>, ω-carboxy deprotected amino acids (34) are  
20 reacted with, for example, chiral α-hydroxy α-substituted acid  
esters where the hydroxyl moiety is converted to a leaving  
group, for example, Triflate. The use of Triflate as the  
leaving group was found to be superior to other leaving groups  
such as halogens, Tosyl, Mesyl; etc., because it prevents the  
25 β-elimination reaction encountered with the other leaving  
groups. The use of Triflate as the leaving group also ensures  
high optical purity of the product, for example (36). The  
temporary N<sup>α</sup> protecting group, such as Bzl, and the α-carboxyl  
protecting group, such as benzyl ester, are concomitantly  
30 removed by mild condition, such as catalytic hydrogenation,  
that to not remove the ω-carboxy protecting group such as t-Bu  
to give the N<sup>α</sup> (protected ω-carboxy alkylene) amino acid (36).  
Introduction of the N<sup>α</sup> protecting group suitable for peptide  
synthesis is accomplished by methods well known in the art.

The choice of the N<sup>α</sup> and the ω-carboxy protecting groups is dictated by the use of the building units in peptide synthesis. The protecting groups have to be orthogonal to each other and orthogonal to the other side chains protecting groups in the peptide. A combination of N<sup>α</sup> and ω-carboxy protecting groups are for example: N<sup>α</sup>-Fmoc, ω-carboxy t-Bu; N<sup>α</sup>-Fmoc, ω-carboxy Alloc; N<sup>α</sup>-Boc, ω-carboxy Alloc. These combinations are suitable for peptide synthesis and backbone cyclization, either on solid support or in solution.

10 (Scheme VI)

Preparation of N<sup>α</sup>, ω-carboxy protected ω-carboxy alkylene glycine building units.

One preferred procedure for the preparation of protected N<sup>α</sup>(ω-carboxy alkylene)glycines involves the N<sup>α</sup>-alkylation of suitably N<sup>α</sup>, ω-carboxy deprotected amino acids(34) with commercially available α-activated carboxylic acid esters for example, benzyl bromo acetate. Since the titled compound is achiral, the use of leaving groups such as Trf, Tos or Mes is not necessary.

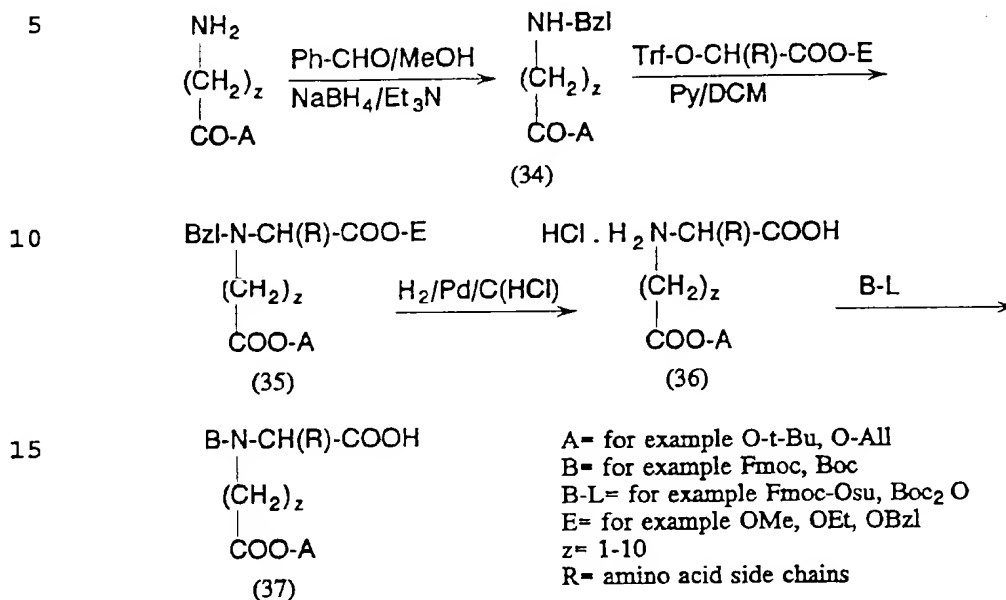
20 The use of the same temporary protecting groups for the N<sup>α</sup> and the α-carboxy groups, for example the Bzl protecting group, ensures the prevention of the undesired dialkylation side reaction and allows concomitant removal of the temporary protecting groups thus giving high yield of the N<sup>α</sup>(protected ω-carboxy alkylene) glycines (39). Introduction of the N<sup>α</sup> protecting group suitable for peptide synthesis is accomplished by methods well known in the art, to give the protected N<sup>α</sup>(ω protected carboxy alkylene) glycines (40).

30 The choice of the N<sup>α</sup> and the ω-carboxy protecting groups is dictated by the use of the building units in peptide synthesis. The protecting groups have to be orthogonal to each other and orthogonal to the other side chains protecting groups in the peptide. A combination of N<sup>α</sup> and ω-carboxy protecting groups are, for example: N<sup>α</sup>-Fmoc, ω-carboxy t-Bu

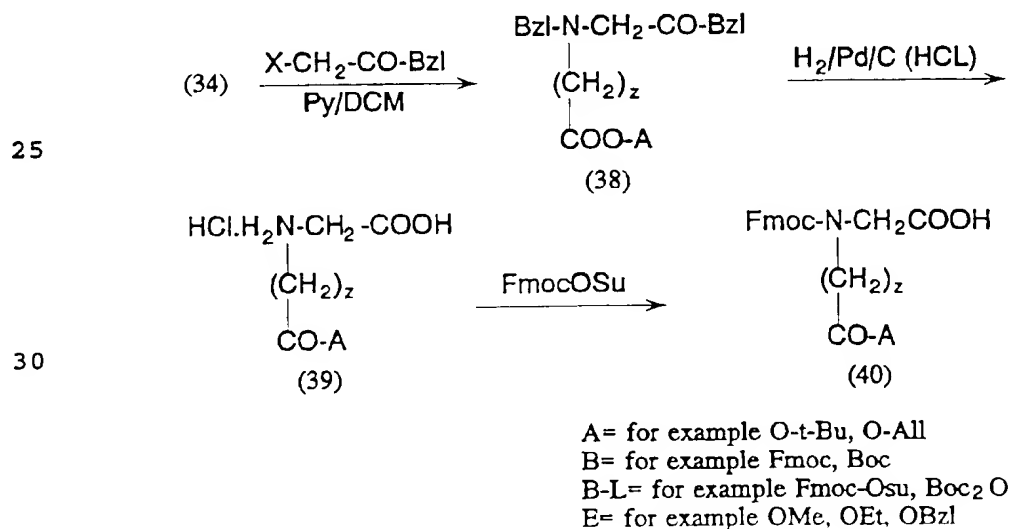
cyclization, either on solid support or in solution.



## SCHEME V



## SCHEME VI



## (Scheme VII)

Preparation of N<sup>α</sup> S<sup>ω</sup>protected ω-thio alkylene amino acid building units.

5 One preferred procedure for the preparation of N<sup>α</sup>, S<sup>ω</sup>-deprotected N<sup>α</sup>(ω-thio alkylene) amino acids involves the N<sup>α</sup>-alkylation of suitably S<sup>ω</sup> protected ω-thio amino alkanes. Suitable S<sup>ω</sup> protecting groups are, for example, Bzl, t-Bu, Trt. One preferred S<sup>ω</sup>-protected ω-thio amino alkanes is for  
10 example ω-(S-Benzyl) amino alkanes (41). One preferred procedure for the preparation of the starting material (41) involves the use of salts of S-protected thiols as nucleophiles for a nucleophilic substitution reaction on  
15 suitably N<sup>α</sup>-protected ω-activated amino alkanes. Removal of the amino protection gives the starting material (41).

The S-protected ω-thio amino alkanes (41) are reacted with for example chiral α-hydroxy α-substituted acid esters where the hydroxyl moiety is converted to a leaving group for example Triflate. The use of Triflate as the leaving group  
20 was found to be superior to other leaving groups such as halogens, Tosyl, Mesyl etc. because it prevents the β-elimination reaction encountered with the other leaving groups. The use of Triflate as the leaving group also ensures high optical purity of the product for example (42). The  
25 temporary α-carboxyl protecting group, such as methyl ester, is removed by mild condition, such as hydrolysis with base, that to not remove the ω-thio protecting group such as S-Bzl to give the N<sup>α</sup> (S-protected ω-thio alkylene) amino acid (43). Introduction of the N<sup>α</sup> protecting group suitable for peptide  
30 synthesis is accomplished by methods well known in the art, to give the protected N,S protected N<sup>α</sup> (ω-thio alkylene) amino acid (44).

The choice of the N<sup>α</sup> and the ω-thio protecting groups is dictated by the use of the building units in peptide.

groups in the peptide. A combination of N<sup>α</sup> and ω-thio

protecting groups are for example: N<sup>α</sup> Fmoc, S<sup>ω</sup> t-Bu; N<sup>α</sup> Fmoc, S<sup>ω</sup> Bzl; N<sup>α</sup> Fmoc, S<sup>ω</sup> Trt; N<sup>α</sup> Boc, S<sup>ω</sup> Bzl. These combinations are suitable for peptide synthesis and backbone cyclization, either on solid support or in solution.

5

(Scheme VIII)

Preparation of N<sup>α</sup>, S<sup>ω</sup> protected ω-thio alkylene glycine building units.

- 10 One preferred procedure for the preparation of N<sup>α</sup>, S<sup>ω</sup>-deprotected N<sup>α</sup>(ω-thio alkylene) amino acids involves the N<sup>α</sup>-alkylation of suitably S<sup>ω</sup> protected ω-thio amino alkanes (41) with commercially available α-activated carboxylic acid esters for example ethyl bromo acetate. Since the titled compound is  
15 achiral, the use of leaving groups such as Trf, Tos or Mes is not necessary.

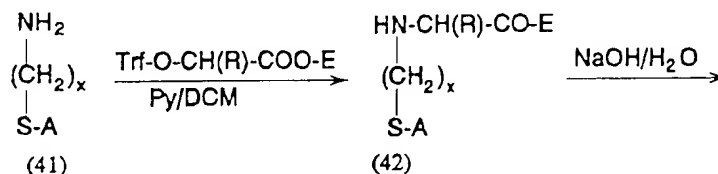
- Suitable protecting groups for the ω-thio groups are for example Bzl, t-Bu, Trt. One preferred S-protected ω-thio amino alkanes is for example ω-(S-Benzyl) amino alkanes (41).  
20 The N-alkylation reaction gives the ester (45). The temporary α-carboxyl protecting group, such as ethyl ester, is removed by mild conditions, such as hydrolysis with base, that to not remove the ω-thio protecting group such as S-Bzl to give the N<sup>α</sup> (S-protected ω-thio alkylene) glycines (46). Introduction  
25 of the N<sup>α</sup> protecting group suitable for peptide synthesis is accomplished by methods well known in the art, to give the protected N<sup>α</sup>, S<sup>ω</sup>-deprotected N<sup>α</sup> (ω-thio alkylene) glycines (47).

- The choice of the N<sup>α</sup> and the ω-thio protecting groups is  
30 dictated by the use of the building units in peptide synthesis. The protecting groups have to be orthogonal to each other and orthogonal to the other side chains protecting groups in the peptide. A combination of N<sup>α</sup> and ω-thio protecting groups are for example: N<sup>α</sup> Fmoc, S<sup>ω</sup> t-Bu; N<sup>α</sup>

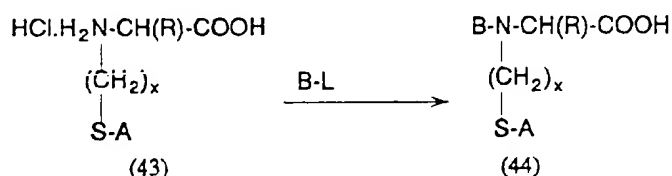
These combinations are suitable for peptide synthesis and backbone cyclization, either on solid support or in solution.

## SCHEME VII

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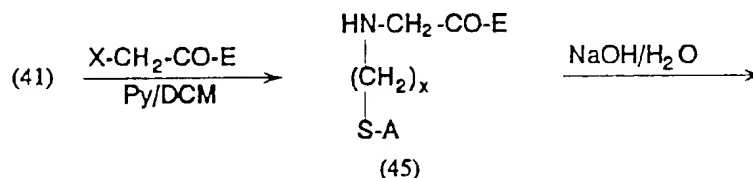


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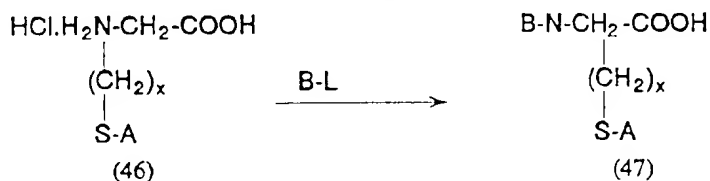
A= for example Bzl, t-Bu, Trt  
 B= for example Fmoc, Boc, Alloc  
 B-L= for example Fmoc-Osu, Boc<sub>2</sub>O, Alloc-Cl  
 E= for example OMe, OEt  
 x= 1-10  
 R= amino acid side chains

## SCHEME VIII

20



25



30

A= for example Bzl, t-Bu, Trt  
 B= for example Fmoc, Boc, Alloc  
 B-L= for example Fmoc-Osu, Boc<sub>2</sub>O, Alloc-Cl  
 E= for example OMe, OEt  
 x= 1-10  
 X= Cl, Br, I.

## SPECIFIC EXAMPLES OF PEPTIDES

Preparation of the novel backbone cyclized peptide analogs using the schematics outlined above will be 5 illustrated by the following non-limiting specific examples:

## EXAMPLE 1

Ada-(D)Arg-Arg-cyclo(N<sup>ε</sup>(1-(6-aminohexylene)Gly-Hyp-Phe-D-Asp)-D-Phe-Phe-Arg-OH

10

## STAGE 1

Boc-Arg(Tos)-O-resin ---> Fmoc-Phe-Arg(Tos)-O-resin

Boc-L-Arg(Tos)-O-resin (0.256 g, 0.1 mmole, 0.39 meq of nitrogen/g) was placed in a shaker flask and swelled for two 15 hours by the addition of DCM. The resin was then carried out through the procedure in Table 1 which includes two deprotections of the Boc protecting group with 55% TFA in DCM for a total of 22 minutes, washing, neutralization with 10% DIEA in NMP and washing (Table 1 steps 1-8). After positive 20 ninhydrin test, as described in Kaiser et al., Anal Biochem., 34:595, 1970 and is incorporated herein by reference in its entirety, coupling (Table 1 steps 9-10) was achieved in NMP by the addition of Fmoc-L-Phe (0.232 g, 0.6 mmole) and after 5 minutes of shaking, solid BOP reagent (0.265 g, 0.6 mmole) was 25 added to the flask.

30

TABLE 1 PROCEDURE FOR 0.1 mmOLE SCALE

	<u>STEP NO.</u>	<u>SOLVENT/ REAGENT</u>	<u>VOLUME (ML)</u>	<u>TIME (MIN)</u>	<u>REPEAT (XS)</u>	<u>COMMENT</u>
5	1	DCM	5	120	1	Swells resin
	2	DCM	5	2	3	
	3	TFA/DCM 55%	5	2	1	Deprotection
	4	TFA/DCM 55%	5	20	1	Deprotection
	5	DCM	5	2	3	
10	6	NMP	5	2	4	check for positive nin.
	7	DIEA/NMP	5	5	2	Neutralization
	8	NMP	5	2	5	
	9	Fmoc-AA in NMP		5	5	Coupling add BOP 6 eq. add DIEA 120 600 1 12 eq. Check pH, adjust to pH 8 with DIEA
15	10	NMP	5	2	5	check for negative nin.
	11	Pip/NMP 20%	5	10	1	Deprotection
	12	Pip/NMP 20%	5	10	1	
20	13	NMP	5	2	6	check for positive nin.

After shaking for 10 minutes, the mixture was adjusted to pH 8 (measured with wetted pH stick) by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 10 hours at ambient temperature. The resin was then washed and subjected to ninhydrin test. After negative ninhydrin test the resin was used for the next coupling.

## STAGE 2

30 Fmoc-Phe-Arg(Tos)-O-resin ----> Fmoc-N<sup>α</sup>(6-Boc amino hexylene)Gly-Hyp(OBzl)-Phe-D-Asp(t-Bu)-D-Phe-Phe-Arg(Tos)-O-resin

The Fmoc-Phe-Arg(Tos)-O-resin (Stage 1) was subjected to two deprotections of the Fmoc protecting group by 20% piperidine in NMP.

described in Stage 1 (Table 1 steps 9-10) using Fmoc-D-Phe (0.232 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and the Fmoc group deprotected as described above (Table 1 steps 11-13).

5 After washing and ninhydrin test, coupling of Fmoc-D-Asp(t-Bu) was achieved as described in Stage 1 (Table 1 steps 9-10) using Fmoc-D-Asp(t-Bu) (0.247 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and the Fmoc group deprotected as described

10 above (Table 1 steps 11-13). After washing and ninhydrin test, coupling of Fmoc-L-Phe was achieved as described in Stage 1 (Table 1 steps 9-10) using Fmoc-L-Phe (0.232 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and the Fmoc group

15 deprotected as described above (Table 1 steps 11-13). After washing and ninhydrin test, coupling of Fmoc-L-Hyp(OBzl) was achieved as described in Stage 1 (Table 1 steps 9-10) using Fmoc-L-Hyp(OBzl) (0.266 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was

20 washed and the Fmoc group deprotected as described above (Table 1 steps 11-13). The resin was washed and subjected to picric acid test (Method K). Coupling of Fmoc-N<sup>ε</sup>(6-Boc amino hexylene) glycine was achieved as described in Stage 1 (Table 1 steps 9-10) using Fmoc-N<sup>ε</sup>(6-Boc amino hexylene)glycine (0.3

25 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was then washed and subjected to the picric acid test (Method K below). After negative test the resin was used for the next coupling.

### 30 STAGE 3

Fmoc-N<sup>ε</sup>(6-Boc amino hexylene)Gly-Hyp(OBzl)-Phe-D-Asp(t-Bu)-D-Phe-Phe-Arg(Tos)-O-resin ----> Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>ε</sup>(6-Boc amino hexylene)Gly-Hyp(OBzl)-Phe-D-Asp(t-Bu)-D-Phe-Phe-Arg(Tos)-O-resin

the protecting group by 20% Fmoc

in NMP (Table 2 steps 1-2). After washing, the picric acid test (Method K) was performed. If the test did not show 98±2%, deprotection of the peptide resin was subjected again to 3 deprotection steps (Table 2 steps 1-2), washing and 5 picric acid test (Method K). Coupling of Fmoc-L-Arg(Tos) was achieved in NMP by the addition of (0.33 g, 0.6 mmole) and after 5 minutes of shaking, solid PyBOP reagent (0.28 g, 0.6 mmole) was added to the flask. After shaking for 10 minutes, the mixture was adjusted to pH 8 (measured with wetted pH 10 stick) by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 2.5 hours at ambient temperature. The resin was then washed and subjected to a second coupling by the same procedure for 20 hours. After washing the resin was subjected to picric acid test (Method K) (Table 2 steps 3-6). If the 15 test did not show 98±2% coupling the peptide resin was subjected again to a third coupling for 2 hours at 50 °C (Table 2 step 7). The resin was washed subjected to three deprotection of the Fmoc protecting group by 20% Pip in NMP (Table 2 steps 1-2). After washing picric acid test (Method 20 K) was performed.

25

30



TABLE 2 PROCEDURE FOR 0.1 mmOLE SCALE

STEP NO.	SOLVENT/ REAGENT	VOLUME (ML)	TIME (MIN)	REPEAT (XS)	COMMENT
1	Piperidine/NMP 20%	5	10	3	Deprotection
5 2	NMP	5	2	6	Picric acid test.
3	Fmoc-AA in NMP add PyBOP add DIEA	5	5 150	1	Coupling 6 eq. 12 eq. Check pH, adjust to pH 8 with DIEA.
10 4	NMP	5	2	3	check for negative nin.
5	Fmoc-AA in NMP add PyBOP add DIEA	5	5 20 hr.	1	Coupling 6 eq. 12 eq. Check pH, adjust to pH 8 with DIEA.
15 6	NMP	5	2	4	Picric acid test. If less than 98±2% coupling repeat Steps 4-5
7	Fmoc-AA in NMP add PyBOP add DIEA	5	5 120	1	Coupling at 50 °C 6 eq. 12 eq. Check pH, adjust to pH 8 with DIEA.
20 8	NMP	5	2	4	

If the test did not show 98±2% deprotection, the peptide resin was subjected again to 3 deprotection steps (Table 2 steps 1-2), washing and the picric acid test (Method K). Coupling of Fmoc-D-Arg(Tos) was achieved in NMP as described in Stage 1 (Table 1 steps 9-10) using Fmoc-D-Arg(Tos) (0.33 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed 6 times with NMP (Table 1 step 15) and used in the next stages.

## STAGE 4

Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>α</sup>(6-Boc amino hexylene)Gly-  
Hyp(OBzl)-Phe-D-Asp(t-Bu)-D-Phe-Phe-Arg(Tos)-O-resin ---->

The Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>ε</sup>(6-Boc amino hexylene)Gly-Hyp(OBzl)-Phe-D-Asp(t-Bu)-D-Phe-Phe-Arg(Tos)-O-resin (Stage 3) was subjected to deprotection of the Boc and t-Bu protecting groups and on resin cyclization according to Table 3. The peptide resin was washed with DCM and deprotected as described in Stage 1 by 55% TFA in DCM. After washing and neutralization by 10% DIEA in NMP and washing 6 times with DCM the peptide resin was dried in vacuo for 24 hours. The dry peptide resin weight, 0.4 g, it was divided into two parts. 0.2 g of the peptide resin was swollen 2 hours in 5 mL NMP and cyclized as follows: Solid TBTU reagent (0.19 g, 6 mmole) was added to the flask. After shaking for 10 minutes, the mixture was adjusted to pH 8 by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 2.5 hours at ambient temperature. The resin was then washed and subjected to a second coupling by the same procedure for 20 hours. After washing the resin was subjected to picric acid test (Method K) (Table 3 steps 8-11). If the test did not show 98±2% cyclization the peptide resin was subjected again to a third cyclization for 2 hours at 50°C (Table 2 step 12). The resin was washed, subjected to three deprotection of the Fmoc protecting group by 20% Pip in NMP (Table 2 steps 1-2). After washing and ninhydrin test, the N-terminal amino group was blocked by Ada. Adamantane acetic acid (0.108 g, 6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole) were added and the flask shaken for 2 hours. After washing 6 times with NMP (Table 2 step 13), ninhydrin test (Method J) was performed. If the test was positive or slightly positive the protecting with adamantane acetic acid was repeated. If the ninhydrin test was negative, the peptide resin was washed 6 times with NMP and 6 times with DCM. The resin was dried under vacuum for 24 hours. The dried resin was subjected to HF as follows: to the dry peptide resin (0.2 g) in the HF reaction flask, anisole (2 mL) was added and the

resin was washed 6 times with DCM and the solid residue dried

in vacuum. The peptide was extracted from the resin with TFA (10 mL, 3 times) and the TFA evaporated under vacuum. The residue was dissolved in 20 mL 30% AcOH and lyophilized. This process was repeated 3 times. The crude peptide was purified 5 by semiprep HPLC (Method H). The final product was obtained as white powder by lyophilization from dioxane, which gave 42 mg (56%) of the title compound.

HPLC (Method G) RT 32.15 minutes, 95%

TOF MS: 1351.4 (M<sup>+</sup>)

10 AAA in agreement with the title compound

[Table 3 follows at this point.]

15

20

25

30

TABLE 3 PROCEDURE FOR 0.05 mMOLE SCALE

STEP NO.	SOLVENT/ REAGENT	VOLUME (ML)	TIME (MIN)	REPEAT (XS)	COMMENT
1	DCM	5	2	3	
2	TFA/DCM 55%	5	2	1	Deprotection
5 3	TFA/DCM 55%	5	20	1	Deprotection
4	DCM	5	2	3	
5	NMP	5	2	4	
6	DIEA/NMP 10%	5	5	2	Neutralization
7	NMP	5	2	5	
8	TBTU/NMP/DIEA	5	150	3	Cyclization
10 9	NMP	5	2	4	Picric acid test. If less than 98±2% coupling perform Steps 10-12. If above 98±2%, go to step 13.
10	TBTU/NMP/DIEA	5	20hr	3	Cyclization. Check pH, adjust to pH 8 with DIEA.
15 11	NMP	5	2	4	Picric acid test. If less than 98±2% coupling perform Steps 12. If above 98±2%, go to step 13
12	TBTU/NMP/DIEA	5	120	3	Cyclization, 50 C Check pH, adjust to pH 8 with DIEA.
20 13	NMP	5	2	6	
14	Pip/NMP 20%	5	10	1	Deprotection
15	Pip/NMP 20%	5	10	1	
25 16	NMP	5	2	6	Check for positive nin.
17	AdacOH/BOP /NMP	5	2	1	
18	NMP	5	2	6	Check for negative nin.
19	DCM	5	2	4	
30					

**EXAMPLE 2 NON-CYCLIZED PEPTIDE (Control for biological assays)**

Ada-D-Arg-Arg-N<sup>o</sup>(6-acetamidohexylene)Gly-Hyp-Phe-D-Asp(NH-Me)-D-Phe-Phe-Arg-OH

The Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>o</sup>(6-amino hexylene)Gly-Hyp(OBzl)-Phe-D-Asp-D-Phe-Phe-Arg(Tos)-O-resin (0.2 g) which was prepared in Example 1 Stage 4 was subjected to acetylation of the 6-amino side chain of N<sup>o</sup>(6-acetamidohexylene)Gly and to methyl amidation of the carboxylic group of D-Asp as described in Table 4. The peptide resin was swollen in 5 mL NMP for 2 hours and AcO (0.113 mL, 12 mmole) and PP (17 mg) were added. After 30 minutes, the resin was washed with NMP 6 times and subjected to ninhydrin test. If the test was positive or slightly positive the acetylation reaction was repeated. If the ninhydrin test was negative, the carboxy group of D-Asp was activated by the addition of HOBT (0.040 g, 0.3 mmole) and DIC (0.047 mL, 0.3 mmole) to the peptide resin in NMP. The mixture was shaken for half an hour and a solution of 30 % methylamine in EtOH (0.2mL) was added. After one hour, the resin was washed 6 times with NMP and the terminal Fmoc group removed by 20% Pip in NMP (Table 4 steps 7-9). After washing with NMP the N-terminal amino group was blocked by Ada as described in Example 1 Stage 4 and the resin was washed with NMP and DCM (Table 4 steps 10-12) and the resin dried in vacuo. The peptide was deprotected and cleaved from the resin by HF. To the dry peptide resin (0.2 g) in the HF reaction flask, anisole (2 mL) was added and the peptide treated with 20 mL liquid HF at -20 °C for 2 hours. After the evaporation of the HF under vacuum, the anisole was washed with ether (20 mL 5 times) and the solid residue dried in vacuo. The peptide was extracted from the resin with TFA (10 mL, 3 times) and the TFA evaporated under vacuum. The residue was dissolved in 20 mL 30% AcOH and lyophilized. This process was repeated 3 times. The crude peptide was purified by

HPLC (Method G) RT 27.70 minutes, 93%

TOF MS: 1424.6 (M<sup>+</sup>)

AAA in agreement with the title compound

5

TABLE 4 PROCEDURE FOR 0.05 mMOLE SCALE

<u>STEP NO.</u>	<u>SOLVENT/ REAGENT</u>	<u>VOLUME (ML)</u>	<u>TIME (MIN)</u>	<u>REPEAT (XS)</u>	<u>COMMENT</u>
1	NMP	5	120	1	Swells resin
2	Ac <sub>2</sub> O/PP/NMP	5	30	1	Protecting of side chain
10 3	NMP	5	2	6	Check for negative nin.
4	DIC/HOBT/NMP	5	30	1	Activation of COOH side chain
5	MeNH <sub>2</sub> /EtOH/	5	60	1	Protecting of side chain
15 6	NMP	5	2	6	
7	Pip/NMP 20%	5	10	1	Deprotection
8	Pip/NMP 20%	5	10	1	
9	NMP	5	2	6	Check for positive nin.
20 10	AdacOH/BOP/NMP	5	2	1	
11	NMP	5	2	6	Check for negative nin.
12	DCM	5	2	4	

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## EXAMPLE 3

5 H-D-Arg-Arg-cyclo(N<sup>ε</sup>(1-(4-propanoyl))Gly-Hyp-Phe-N<sup>ε</sup>(3-amido-propylene)Gly)-Ser-D-Phe-Phe-Arg-OH

## STAGE 1

10 Fmoc-Phe-Arg(Tos)-O-resin ----> Fmoc-N<sup>ε</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)-Phe-N<sup>ε</sup>(3-Boc amino propylene)-Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-O-resin

Fmoc-Phe-Arg(Tos)-O-resin prepared from Boc-Arg(Tos)-O-Resin (0.3 g, 0.1 mmole) (Example 1, Stage 1) was subjected to two deprotection of the Fmoc protecting group by 20%  
 15 piperidine in NMP (Table 1, steps 11-13). After washing and ninhydrin test (Method J), coupling of Fmoc-D-Phe was achieved as described in Stage 1 (Example 1) (Table 1 steps 9-10) using Fmoc-D-Phe (0.232 g, 0.6 mmole), BOP reagent (0.265 g, 0.6  
 20 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and the Fmoc group deprotected as described above (Table 1, steps 11-13). After washing and ninhydrin test (Method J), coupling of Fmoc-Ser(Bzl) was achieved as described in Stage 1 (Example 1) (Table 1 steps 9-10) using Fmoc-Ser(Bzl) (0.25 g,  
 25 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and the Fmoc group deprotected as described above (Table 1, steps 11-13). After washing and picric acid test (Method K), coupling of Fmoc-N<sup>ε</sup>(3-Boc amino propylene)glycine was achieved as described in  
 30 Table 1, steps 9-10 using Fmoc-N<sup>ε</sup>(3-Boc amino propylene)Gly (0.272 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and subjected to three deprotection of the Fmoc protecting group by 20% Pip in NMP (Table 2, steps 1-2). After washing picric

acid test (Method K). Coupling of Fmoc-L-Hyp(OBzl) was achieved in NMP by the addition of Fmoc-L-Hyp(OBzl) (0.33 g, 0.6 mmole) and after 5 minutes of shaking, solid PyBrOP reagent (0.28 g, 0.6 mmole) was added to the flask. After 5 shaking for 10 minutes, the mixture was adjusted to pH 8 by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 2.5 hours at ambient temperature. The resin was then washed and subjected to a second coupling by the same procedure for 20 hours. After washing the resin was subjected 10 to picric acid test (Method K) (Table 2, steps 3-6). If the test did not show  $98 \pm 2\%$  coupling the peptide resin was subjected again to a third coupling for 2 hours at 50 °C. (Table 2, step 7). The resin was washed subjected to three deprotection of the Fmoc protecting group by 20% Pip in NMP 15 (Table 2, steps 1-2). After washing picric acid test (Method K) was performed. If the picric acid test did not show  $98 \pm 2\%$  deprotection, the resin was subjected again to deprotections steps (Table 2, steps 1-2). Coupling of Fmoc-Phe was achieved in NMP by the addition of Fmoc-Phe (0.232 g, 0.6 mmole), BOP 20 reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole). The resin was washed and after picric acid test (Method K) the Fmoc group deprotected as described above (Table 2, steps 1-2). After washing picric acid test (Method K) was performed. If the test did not show  $98 \pm 2\%$  deprotection the peptide resin 25 was subjected again to 3 deprotection steps (Table 2, steps 1-2), washing and picric acid test (Method K). Coupling of N<sup>o</sup>(3-t-Bu carboxy propylene)Gly was achieved as described in Table 1 steps 9-10 using N<sup>o</sup>(3-t-Bu carboxy propylene)Gly (0.264 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and 30 DIEA (0.209 mL, 1.2 mmole). The resin was then washed and subjected to the picric acid test (Method K). After negative test the resin was used for the next coupling.



## STAGE 2

Fmoc-N<sup>α</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)-Phe-N<sup>α</sup>(3-Boc amino propylene)-Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-O-resin ----->  
Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>α</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)-  
 5 Phe-N<sup>α</sup>(3-Boc amino propylene)-Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-  
O-resin

Fmoc-N<sup>α</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)-Phe-N<sup>α</sup>(3-Boc amino propylene)-Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-O-resin (Stage 1) was subjected to three deprotection of the Fmoc  
 10 protecting group by 20% Piperidine in NMP (Table 2, steps 1-2). After washing picric acid (Method K) test was performed. If the test did not show 98±2% deprotection the peptide resin was subjected again to 3 deprotection steps (Table 6, steps 1-2), washing and picric acid test. Coupling of Fmoc-L-Arg(Tos)  
 15 was achieved in NMP by the addition of (0.33 g, 0.6 mmole) and after 5 minutes of shaking, solid PyBroP reagent (0.28 g, 0.6 mmole) was added to the flask. After shaking for 10 minutes, the mixture was adjusted to pH 8 by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 2.5 hours at  
 20 ambient temperature. The resin was then washed and subjected to a second coupling by the same procedure for 20 hours. After washing the resin was subjected to picric acid test (Method K) (Table 2, steps 3-6). If the test did not show 98±2% coupling the peptide resin was subjected again to a  
 25 third coupling for 2 hours at 50°C. (Table 2, step 7). The resin was washed subjected to three deprotection of the Fmoc protecting group by 20% Pip in NMP (Table 2, steps 1-2). After washing picric acid test (Method K) was performed. If the test did not show 98±2% deprotection the peptide resin was  
 30 subjected again to 3 deprotection steps (Table 2, steps 1-2), washing and picric acid test (Method K). Coupling of Fmoc-D-Arg(Tos) was achieved in NMP as described in Stage 1 (Table 1, steps 9-10) using Fmoc-D-Arg(Tos) (0.33 g, 0.6 mmole), BOP reagent (0.265 g, 0.6 mmole) and DIEA (0.209 mL, 1.2 mmole).

## STAGE 3

Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>o</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)-  
Phe-N<sup>o</sup>(3-Boc amino-propylene)Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-  
O-resin -----> H-D-Arg-Arg-cyclo(N<sup>o</sup>(4- propanoyl))Gly-Hyp-Phe-  
 5 N<sup>o</sup>(3-amido-propyl)Gly)-Ser-D-Phe-Phe-Arg-OH

Fmoc-D-Arg(Tos)-Arg(Tos)-N<sup>o</sup>(4-t-Bu-propanoyl)Gly-Hyp(OBzl)- Phe-N<sup>o</sup>(3-Boc amino-propylene)Gly-Ser(Bzl)-D-Phe-Phe-Arg(Tos)-O-resin (Stage 2) was subjected to deprotection of the Boc and t-Bu protecting groups and on resin cyclization  
 10 according to Table 5. The peptide resin was washed with DCM and deprotected as described in Stage 1 by 55% TFA in DCM. After washing and neutralization by 10% DIEA in NMP and washing 6 times with and NMP (Table 5, steps 1-5) the peptide was cyclized as follow: solid TBTU reagent (0.19 g, 6 mmole)  
 15 was added to the flask. After shaking for 10 minutes, the mixture was adjusted to pH 8 by the addition of DIEA (0.209 mL, 1.2 mmole) and the flask shaken for 2.5 hours at ambient temperature. The resin was then washed and subjected to a second coupling by the same procedure for 20 hours. After  
 20 washing the resin was subjected to picric acid test (Method K) (Table 3, steps 8-11). If the test did not show 98±2% cyclization the peptide resin was subjected again to a third cyclization for 2 hours at 50°C. (Table 2, step 12). The resin was washed, subjected to three deprotection of the Fmoc  
 25 protecting group by 20% Pip in NMP (Table 5, steps 14-15). After washing 6 times with NMP and 4 times with DCM, the resin was dried in vacuo for 24 hours. The dried resin was subjected to HF as follows: to the dry peptide resin (0.4 g) in the HF reaction flask, anisole (2 mL) was added and the  
 30 peptide treated with 20 mL liquid HF at -20°C for 2 hours. After the evaporation of the HF under vacuum, the anisole was washed with ether (20 mL, 5 times) and the solid residue dried in vacuo. The peptide was extracted from the resin with TFA (10 mL, 3 times) and the TFA evaporated and the peptide

purified by semipreparative HPLC (Method H). The final

product was obtained as white powder by lyophilization from dioxane, which gave 59 mg ( 34%) of the title compound.

5 [Table 5 follows at this point.]

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TABLE 5 PROCEDURE FOR 0.1 mmOLE SCALE

	STEP NO.	SOLVENT/ REAGENT	VOLUME (ML)	TIME (MIN)	REPEAT (XS)	COMMENT
	1	DCM	10	2	3	
5	2	TFA/DCM 55%	10	2	1	Deprotection
	3	TFA/DCM 55%	10	20	1	Deprotection
	4	DCM	10	2	3	
10	5	NMP	10	2	4	
	6	DIEA/NMP 10%	10	5	2	Neutralization
	7	NMP	10	2	5	
	8	TBTU/NMP / DIEA	10	150	3	Cyclization
15	9	NMP	10	2	4	Picric acid test. If less than 98±2% Coupling perform Steps 10.
20	10	TBTU/NMP / DIEA	10	20h	3	Cyclization, Check pH, adjust to pH 8 with DIEA.
	11	NMP	10	2	4	Picric acid test. If less than 98±2% coupling perform Step 12.
25	12	TBTU/NMP / DIEA	10	120	3	Cyclization, 50 °C Check pH, adjust to pH 8 with DIEA.
	13	NMP	10	2	6	
30	14	Piper- idine/ NMP 20%	10	10	1	Deprotection
	15	Piper- idine/ NMP 20%	10	1		

HPLC (Method G) RT 33.62 minutes (91%)  
TOF MS: 1278 (M<sup>+</sup>)  
AAA in agreement with the title compound

#### EXAMPLE 4

5

H-D-Arg-Arg-cyclo(N<sup>α</sup>(4-propanoyl)Gly-Hyp-Phe-N<sup>α</sup>(3-amido-propyl)-S-Phe)-Ser-D-Phe-Phe-Arg-OH

Title compound was synthesized according to Example 3 except that in stage 1, Fmoc-N<sup>α</sup>(3-Boc-amino-propylene)-S-Phe (0.326) was substituted for Fmoc-N<sup>α</sup>(3-Boc amino propylene)Gly.  
10 A total of 0.643 g Boc-L-Arg(Tos)-O-resin (0.39 meq/g, 0.250 mmole) was used and reagent quantities were adjusted accordingly. Cyclic peptide yield (from half the total resin used) was 74 mg (42%) of the title compound.

15

#### SPECIFIC EXAMPLES OF BUILDING UNITS

The following specific examples of novel building units are provided for illustrative purposes not meant to be limiting. The following is described in sections, including  
20 "Procedures", "Methods", "Compounds" and "EXAMPLES".  
"Procedures" are detailed stepwise descriptions of synthetic procedures according to the more general schemes. "Methods" are general descriptions of analyses used to determine the progress of the synthetic process. Numbered "Compounds" are  
25 either the starting material or intermediates for further numbered "Compounds" the synthesis of which progresses according to the specified "Procedure." Several "Compounds" used in series produce "EXAMPLES" of novel building units of the present invention. For instance, "Compounds" 27-29, 41-  
30 44, 46-47, 51-55, 62, 63, 67 and 76-79 are actually "EXAMPLES" 5-25, respectively, of novel building units of the present invention. "Compounds" 1-26, 30-40, 45, 48-50, 56-61, 64-66, 68-75 are starting materials or intermediates (only) for the

Procedure 1

Synthesis of N-Boc alkylene diamines (BocNH(CH<sub>2</sub>)<sub>n</sub>NH<sub>2</sub>) (known compounds).

To a solution of 0.5 mole alkylene diamine in 0.5 L  
5 CHCl<sub>3</sub>, cooled in an ice-water bath, was added dropwise, with  
stirring, a solution of 10.91 g (0.05 mole) Boc<sub>2</sub>O in 0.25 L  
CHCl<sub>3</sub>, for 3 h. The reaction mixture was stirred for 16 h. at  
room temperature and then washed with water (8 X 250 mL). The  
organic phase was dried over Na<sub>2</sub>SO<sub>4</sub> and evaporated to dryness  
10 in vacuo.

Procedure 2

Synthesis of N-Boc, N-Bzl alkylene diamines (BocNH(CH<sub>2</sub>)<sub>n</sub>NH-Bzl).

15 To a solution of 0.05 mole of mono Boc alkylene diamine  
in 60 mL MeOH was added 2.77 mL (0.02 mole) Et<sub>3</sub>N, 9.02 g  
(0.075 mole) MgSO<sub>4</sub>, and 5.56 mL (0.055 mole) of freshly  
distilled benzaldehyde. The reaction mixture was stirred  
under room temperature for 1.5 h. Then 11.34 g (0.3 mole) of  
20 NaBH<sub>4</sub> were added in small portions during 0.5 h with cooling  
to -5°C. The reaction mixture was then stirred for 1 h at -  
5°C and for another 1 h at 0°C. The reaction was stopped by  
addition of 200 mL water and the product was extracted with  
EtOAc (3 X 200 mL). The combined EtOAc extracts were washed  
25 with water (4 X 100 mL). The organic phase was extract with  
0.5 N HCl (4 X 100 mL) and the aqueous solution was  
neutralized under cooling with 25 mL 25% NH<sub>4</sub>OH, extracted with  
CHCl<sub>3</sub> (3 X 100 mL) and the combined extracts were washed with  
water (3 X 80 mL), dried over Na<sub>2</sub>SO<sub>4</sub> and evaporated to dryness  
30 in vacuo.

Procedure 3

Synthesis of (R) or (S) α-hydroxy acids (known compounds).

To a solution of 10.50 g (0.1 mole) (R) or (S) amine

and cooling in an ice bath. The reaction mixture was stirred

3 h. at 0°C and additional 18 h at room temperature, then the (R)- or (S)- hydroxy acid was extracted with ether in a continuous ether extractor. The ethereal solution was washed with 1N HCl (2x50 mL), H<sub>2</sub>O (3x80 mL), dried over Na<sub>2</sub>SO<sub>4</sub> and 5 evaporated to dryness. The product was triturated twice from ether:petrol-ether (40-60°C) (1:10). The precipitate was filtered, washed with 50 mL petrol-ether and dried.

#### Procedure 4

#### 10 Synthesis of (R) or (S) $\alpha$ -hydroxy acid methyl esters (known compounds).

To a suspension of 0.065 mole (R)- or (S)- hydroxy acid in 100 mL ether was added under cooling in an ice bath 300 mL of an ethereal solution of CH<sub>2</sub>N<sub>2</sub> until stable yellow color of 15 reaction mixture was obtained. Then the ether solution was washed with 5% KHCO<sub>3</sub> (3x100 mL) and H<sub>2</sub>O (2x80 mL), dried over Na<sub>2</sub>SO<sub>4</sub> and evaporated to dryness. The product was dried in vacuo.

#### 20 Procedure 5

#### Synthesis of triflate of (R) or (S) $\alpha$ -hydroxy acid methyl esters.

To a cooled solution of 2.67 mL (0.033 mole) pyridine in 20 mL dry DCM was added 5.55 mL (0.033 mole) Trf<sub>2</sub>O at -20°C 25 (dry ice in EtOH bath), then after 5 min a solution of 0.03 mole (R) or (S)  $\alpha$ -hydroxy acid methyl ester in 20 mL dry DCM was added dropwise. The reaction mixture was stirred at room temperature for 45 min, then was passed through a short silica gel column (2 cm). The product was eluted with 400 mL of 30 petrol-ether:methylene-chloride (1:1). The solvent was evaporated in vacuo.

#### Procedure 6

Synthesis of (R) or (S)  $\alpha$ -hydroxy acid methyl esters (known compounds)

diamine in 20 mL of dry DCM was added 3.04 mL (0.022 mole)

Et<sub>3</sub>N. Then a solution of 0.02 mole of (R) or (S)  $\alpha$ -hydroxy acid methyl ester triflate in 25 mL dry DCM was added dropwise (0.5 h.) under cooling in an ice-water bath. The reaction mixture was stirred at room temperature for 18 h. Then 150 mL of CHCl<sub>3</sub> was added and the yellow solution was washed with water (3 X 80 mL). The organic phase was dried over Na<sub>2</sub>SO<sub>4</sub> and adsorbed on silica-gel and dried in vacuo. The silica-gel was washed on filter with 0.5 L of petrol-ether and with 0.5 L of 2% EA in PE. Then the product was eluted from silica with 0.5 L of mixture petrol-ether:ethyl-acetate (4:1). The solvent was evaporated in vacuo. If the product was not clean it was further purified on a small column of silica-gel (250 mL). The first impurities were eluted with 0.8 L of hexane then the product was eluted with 1.5 L of mixture of petrol-ether: ethyl-acetate (4:1).

#### Procedure 7

##### Hydrolysis of methyl esters

To a solution of 0.015 mole of methyl ester in 40 mL MeOH was added 10 mL 7.5 N NaOH cooled in an ice-water bath. The reaction mixture was stirred at room temperature for approximately 24 h (until the methyl ester spot disappears on TLC). Then 100 mL of water were added and the reaction mixture was washed with petrol-ether (3 X 80 mL). The aqueous solution was acidified under cooling by addition of 40 mL 2N HCL. The product was extracted with a mixture of CHCl<sub>3</sub>:i-PrOH (3:1) (3 X 80 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, evaporated to dryness and dried in vacuo to obtain a white foam in quantitative yield.

30

#### Procedure 8

##### Removal of Bzl by Hydrogenation with Pd/C

To a solution of 0.012 mole (R) or (S) N<sup>o</sup> (Bzl) (N<sup>o</sup>-Boc-amino alkylene) amino acid in 60 mL MeOH-DMF (1:1) was added

mixture of 2M MeOH:H<sub>2</sub>O:glacial AcOH (1:1:1) was added.



The catalyst was filtrated off and washed (is the acetic acid?) with H<sub>2</sub>O or MeOH (2X15 mL). The combined filtrate was evaporated to dryness and recrystallized from methanol: ether (15 mL:250). The precipitate was filtered and dried in vacuo.

5

#### Procedure 9

Synthesis of (R) or (S) N<sup>o</sup> (Fmoc) (N<sup>w</sup>-Boc-amino alkylene ) amino acid.

To 50 mL water was added 0.07 mole of (R) or (S) N<sup>o</sup> (N<sup>w</sup>-Boc-amino alkylene) amino acid and 1.95 mL (0.014 mole) Et<sub>3</sub>N. The suspension was stirred 2-3 h until a clear solution was obtained. Then a solution of 2.25 g (0.07 mole) of FmocOSu in 100 mL ACN was added. The reaction mixture was stirred 18 h at room temperature, then 150 mL water was added and the solution was washed with petrol-ether (3 X 100 mL) and with ether:petrol-ether (1:4). The aqueous solution was acidified by addition of 14 mL 1N HCL. The product was extracted with EtOAc (4 X 100 mL) and the organic phase was washed with 0.5 N HCl (2 X 50 mL), H<sub>2</sub>O (3 X 80 mL), dried over Na<sub>2</sub>SO<sub>4</sub>, evaporated to dryness and recrystallized from ether: petrol-ether (80 mL: 200 mL)

#### Procedure 10

Synthesis of S-benzylcysteamine (Bzl-S-(CH<sub>2</sub>)<sub>2</sub>-NH<sub>2</sub>) (known compound).

To a suspension of 0.1 mole cysteamine hydrochloride in 20 mL methanol were added 13.6 mL of 25% ammonia solution, followed by dropwise addition of 0.12 mole benzyl bromide at room temperature. The mixture was stirred for 0.5 h, and the formed precipitate of S-dibenzylcysteamine was collected by filtration. The product was extracted with ether (3 X 100 mL) and the organic phase was successively washed with brine (2 X 100 mL), dried over MgSO<sub>4</sub> and the solvent evaporated in vacuo. The crude product was essentially pure enough for the

Procedure 11

Synthesis of N<sup>ω</sup>-(ω-(benzylthio)alkylene)phthalimides ((Bzl-S-(CH<sub>2</sub>)<sub>n</sub>-N=Pht)) (known compounds).

N-(ω-bromoalkylene)phthalimide (0.1 mole) and benzyl mercaptane (0.11 mole) were stirred with 0.1 mole potassium carbonate in 100 mL DMSO at 50°C for 24 hours. The mixture was poured into ice-water and the product was allowed to crystallize for 0.5 hour, collected by filtration and recrystallized from i-PrOH.

10

Procedure 12

Synthesis of N<sup>ω</sup>-(ω-(benzylthio)alkyl)amines (Bzl-S-(CH<sub>2</sub>)<sub>n</sub>-NH<sub>2</sub>) (known compounds).

Hydrazinolysis of the phthalimide group was performed by refluxing 0.09 mole of N<sup>ω</sup>-(ω-(benzylthio)alkylene)-phthalimide (Procedure 11) with 120 mL 1M solution of hydrazine hydrate in ethanol (diluted with additional 220 mL ethanol) for 2 hours. The formed precipitate was collected by filtration and hydrolyzed with 180 mL 2N HCl at 50°C for 0.5 hour. The water was evaporated in vacuo and the crude hydrochloride dissolved in 50 mL 25% ammonia solution. The free amine was extracted with DCM (4 X 100 mL) and the organic phase was washed with brine (2 X 100 mL), dried over MgSO<sub>4</sub>, and the solvent evaporated in vacuo. The crude N-(ω-(benzyl-thio)alkyl)amine was distilled under reduced pressure, and appeared as colorless oil, which could be kept refrigerated under nitrogen for prolonged periods.

Procedure 13

Synthesis of (R) and (S) N<sup>ω</sup>-(ω-(benzylthio)alkylene) amino acids methyl esters ((R) or (S) (Bzl-S-(CH<sub>2</sub>)<sub>n</sub>-NH-CH(R)-COOMe)).

To a solution of 15 mmol N-(ω-(benzylthio)alkyl)amine

in 55 mL DCM at 0°C the reaction mixture was then stirred at room temperature for 18 h. The mixture was

then diluted with 100 mL DCM and washed with water (3 X 100 mL). The crude product was cleaned on a silica-gel column with DCM:MeOH(99:1), and was further crystallized from DIE:hexane.

- 5 In the case of Glycine, bromoacetic acid esters were suitable starting materials. Identical results were obtained when both these substrates were reacted with N-( $\omega$ -(benzylthio)alkyl)amines.

#### 10 Procedure 14

Synthesis of (R) or (S) Boc-N<sup>o</sup>-( $\omega$ -(benzylthio)alkylene) amino acids ((R) or (S) (Bzl-S-(CH<sub>2</sub>)<sub>n</sub>-N(Boc)-CH(R)-COOH)).

- 10 mmol (R) or (S) N-( $\omega$ -(benzylthio)alkylene) amino acid methyl ester was dissolved in 50 mL 1,4-dioxane and 50 mL 15 1N NaOH were added. The mixture was stirred at room temperature overnight. The disappearance of the starting material was followed by TLC (Silica gel+ F<sub>254</sub>, CHCl<sub>3</sub>:MeOH-1:4). When all the ester was hydrolyzed, 50 mL water were added, followed by 30 mmol Boc<sub>2</sub>O. The mixture was stirred 20 overnight, then the dioxane was evaporated in vacuo, the mixture was cooled in an ice-water bath, covered with 100 mL EtAc and acidified with saturated KHSO<sub>4</sub> to pH 2-3. The layers were separated, and the aqueous layer was extracted with additional 2X 100 mL EtOAc. The organic layer was washed with 25 water (2 X 100 mL), dried over MgSO<sub>4</sub> and the solvent evaporated in vacuo. The crude product was cleaned on a silica-gel column with DCM:MeOH-99:1 or crystallized from DIE:hexane.

#### 30 Procedure 15

Synthesis of dipeptides (S,S)-Boc-amino acid-N<sup>o</sup>-( $\omega$ -(benzylthio)alkylene) amino acids esters.

A solution of 1.1 mmol Boc-amino acid, 1 mmol N<sup>o</sup>-( $\omega$ -(benzylthio)alkylene) amino acid ester, 1.1 mmol BOP and 3

10 mL of DMF was stirred at room temperature for 1 hour. The mixture was diluted with 40 mL of DCM and washed successively with saturated KHSO<sub>4</sub> (3 X 100 mL).

saturated  $\text{KHCO}_3$  (3 X 100 mL) and brine (2 X 100 mL), dried over  $\text{MgSO}_4$ , and the solvent evaporated in vacuo. The crude product was cleaned on a silica-gel column with  $\text{DCM}:\text{MeOH}$ -99:1 or crystallized from  $\text{DIE}:\text{hexane}$ .

5

#### Procedure 16

Synthesis of  $\text{N}^\alpha$ -Bzl  $\omega$ -amino acids t-butyl esters ( $\text{Bzl-NH-}(\text{CH}_2)_n\text{-COO-t-Bu}$ ).

A solution of 0.05 mole of amino acid t-butyl ester acetate in 200 mL  $\text{H}_2\text{O}$  was acidified to pH 2 with  $\text{AcOH}$ , washed with PE (70 mL X5) cooled and the pH adjusted to 9 by  $\text{NH}_4\text{OH}$  25%. The free amino acid t-butyl ester was extracted with  $i\text{-Pr}:\text{CHCl}_3$  (3:1, 3X100 mL). The combined extracts were dried on  $\text{Na}_2\text{SO}_4$  and evaporated to dryness under vacuum. The benzylation reaction was performed according to Procedure 2.

#### Procedure 17

Synthesis of  $\text{N}^\alpha$ -(Bzl) ( $\omega$ -Bu carboxy alkylene) glycine Bzl ester ( $\text{N}^\alpha$ -(Bzl)  $(\text{CH}_2)_n\text{-COO-t-Bu}(\text{CH}_2)_m\text{-COO-Bzl}$ ).

To a stirred solution of 0.015 mole of N-Bzl  $\omega$ -amino acid t-butyl ester in 10 mL DMF at  $0^\circ\text{C}$  were added 2.61 mL of DIEA and 2.38 mL of benzyl bromo acetate. The reaction mixture was stirred 30 min at  $0^\circ\text{C}$  and 3 h at room temperature. After the addition of 200 mL of ether, the precipitate was removed by filtration and the organic phase washed with  $\text{H}_2\text{O}$  (3X80 mL), 1N HCl (3X80 mL),  $\text{H}_2\text{O}$  (3X80 mL), dried over  $\text{Na}_2\text{SO}_4$  and evaporated to dryness under vacuum. The resulting oil was dried under vacuum.

### 30 METHODS

ANALYTICAL TLC was performed on TLC plates of silica gel E (Merck  $\text{F}_{254}$ ), using the following solvent systems:

METHOD A  $\text{DCM}:\text{MeOH}:\text{AcOH}$  10:4:0.5

METHOD B  $\text{DCM}:\text{MeOH}$  10:1

METHOD C  $\text{EtOAc}:\text{H}_2\text{O}$  1:1

METHOD D  $\text{CHCl}_3:\text{EtOAc}$  4:1

METHOD E PE: EtOAc 9:1

METHOD F CHCl<sub>3</sub>: EtOAc 19:1

METHOD G ANALYTICAL REVERSE PHASE HPLC

5 Column Merck LICHROART RP-18 5  $\mu$ m, 250X4 mm.

Mobile Phases A = 0.1% TFA in H<sub>2</sub>O

B = 0.1% TFA in ACN

Gradient T = 0-5 min A(75%), B(25%)

T = 30 min A(50%), B(50%)

10 T = 40 min A(100%), B(0%)

T = 50 min A(100%), B(0%)

Flow = 1 mL/minute Temperature = 23 °C

METHOD H - SEMIPREPARATIVE REVERSE PHASE HPLC

15 The crude peptide was dissolved in MeOH (1mL) and chromatographed using reverse phase semipreparative HPLC with the following conditions:

Column Merck Hibar LICHROSORB RP-18 7  $\mu$ m, 250 X 410 mm

Mobile Phases A = 0.1% TFA in H<sub>2</sub>O

20 B = 0.1% TFA in ACN

Gradient T = 0-10 min A(80%), B(20%)

T = 60 min A(100%), B(0%)

T = 70 min A(100%), B(0%)

Flow = 4 mL/minute Temperature = 23°C

25

METHOD J NINHYDRIN TEST (NIN. TEST)

The test was performed according to Kaiser et al. Anal.

Biochem., 34:595 (1970) which is incorporated herein by reference in its entirety. Test was considered negative when

30 the resin did not change color after heating to 11°C for 2 minutes with the test mixture. Test was considered positive or slightly positive when the resin was dark or faint purple after heating to 110°C for 2 minutes with the test mixture.

\_\_\_\_\_

This test was performed after removal of the Fmoc protecting group from the amino acid preceding the

coupling of protected N $\alpha$ ( $\omega$ -alkylene) building unit. This absorbance was taken as 100% free amines. After coupling the test was used to check yield of % coupling by comparison.

The resin 0.1 mmole was treated according to steps 1-8, Table 1. After step 8 the resin was introduced into a centrifuge tube and shaken with 40 mL of 5% DIEA:95% DCM for ten minutes. The resin was centrifuged 5 minutes and 4 mL of the solution were pipette into 40 mL. EtOH and the absorbance at 358 nm measured. This procedure was repeated 3 times and the average absorbance calculated.

**TABLE 6 PROCEDURE FOR 0.1 mmOLE SCALE**

STEP NO.	SOLVENT/ REAGENT	VOLUME (ML)	TIME (MIN)	REPEAT (XS)	COMMENT
1	NMP	10	1	3	
2	DCM	10	1	2	
3	Picric acid 0.05M/DCM	10	1	2	
4	DMF	10	0.5	10	
5	NMP	10	1	2	
6	NMP	10	2	3	
7	10% EtOH/DCM	10	1	1	
8	DCM	10	1	2	

20

#### COMPOUND 1

##### N-Boc diamino ethane (known compound)

A solution of 33.4 mL of ethylene diamine in CHCl<sub>3</sub> and 10.91 g of Boc<sub>2</sub>O were used (Procedure 1). Yield 97% of colorless oil.

TLC (Method A) R<sub>f</sub> 0.2-0.24 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound

#### 30 COMPOUND 2

##### N-Boc 1,3 diamino propane (known compound).

A solution of 41.7 mL of 1,3 diamino propane in CHCl<sub>3</sub> and 10.91 g of Boc<sub>2</sub>O were used (Procedure 1). Yield 96% of colorless oil

MS (ESI), reference with the known compound

COMPOUND 3N-Boc 1,4 diamino butane (known compound).

A solution of 44.08 g of 1,4 diamino butane and 10.91 g of Boc<sub>2</sub>O were used (Procedure 1). Yield 98% of white oil.

5 TLC (Method A) Rf 0.32-0.35 (one spot).

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 4N-Boc 1,6 diamino hexane (known compound).

10 A solution of 58.10 g of 1,6 diamino hexane in CHCl<sub>3</sub> and 10.91 g of Boc<sub>2</sub>O were used (Procedure 1). Yield 70% of colorless oil after purification on a silica gel column and elution with CHCl<sub>3</sub>-MeOH (4:1).

TLC (Method A) Rf 0.50-0.54 (one spot)

15 NMR (CDCl<sub>3</sub>) in agreement with the title compound

COMPOUND 5N-Boc, N-Bzl 1,2 diamino ethane

A solution of 8.01 g of Boc ethylene diamine (COMPOUND 20 1) was used (Procedure 2). Yield 65% of colorless oil.

TLC (Method A) Rf 0.62-0.65 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound

COMPOUND 6

25 N-Boc, N-Bzl 1,3 diamino propane.

A solution of 8.71 g of N-Boc 1,3 diamino propane (COMPOUND 2) was used (Procedure 1). Yield 75% of colorless.

TLC (Method A) Rf 0.63-0.68 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound

30 COMPOUND 7

N-Boc, N-Bzl 1,4 diamino butane

A solution of 9.41 g of N-Boc 1,4 diamino butane (Compound 3) was used (Procedure 1). Yield 63% of white oil.

COMPOUND 8N-Boc, N-Bzl 1,6 diamino hexane

A solution of 10.82 g of N-Boc 1,6 diamino hexane (Compound 4) was used (Procedure 1). The ethyl acetate solution after extraction was dried over  $\text{Na}_2\text{SO}_4$  and evaporated under vacuum to dryness. The remaining crude product was dissolved in 400 mL chloroform and washed with 0.5 N HCl (3 X 80 mL, 0.12 mole), water (2 X 100 mL) dried over  $\text{Na}_2\text{SO}_4$  and evaporated to dryness. Then 200 mL of ether was added. The precipitate was filtered, washed with ether (3 X 50 mL) and dried under vacuum.

Yield 70% of white solid mp 150-152°C.

TLC (Method A) Rf 0.8 (one spot)

To remove HCl from product with n=6, the HCl salt was dissolved in  $\text{CHCl}_3$ , washed with an alkali solution (0.5%  $\text{NH}_4\text{OH}$ ), dried over  $\text{Na}_2\text{SO}_4$  and evaporated to dryness. NMR ( $\text{CDCl}_3$ ) in agreement with the title compound.

COMPOUND 920 (S)-3-Phenylacetic acid methyl ester (known compound)

A suspension of 10.8 g of (S)-3-Phenylacetic acid in 100 mL ether was treated with diazomethane (Procedure 4). Yield 85%.

TLC (Method B) Rf 0.6-0.65 (one spot)

25  $(\alpha)_D^{25} = +3.3$  (c=1, MeOH)

NMR ( $\text{CDCl}_3$ ) in agreement with the title compound

COMPOUND 10(R)-3-Phenylacetic acid methyl ester (known compound).

30 A suspension of 10.8 g (R)-3-Phenylacetic acid in 100 mL ether was treated with diazomethane (Procedure 4). Yield 84%.

TLC (Method B) Rf 0.6-0.65 (one spot)

$(\alpha)_D^{25} = -3.3$  (c=1 MeOH)



COMPOUND 11(S)-O-Trf-3-Phenylacetic acid methyl ester

To a cooled solution of Trf<sub>2</sub>O and pyridine in dry DCM (Procedure 5), a solution of 5.4 g of (S)-3-Phenylacetic acid methyl ester was added. After the workup (Procedure 5), the yield was 74%. The product was used immediately or kept in a cold desiccator under Ar.

COMPOUND 1210 (R)-O-Trf-3-Phenylacetic acid methyl ester

To a cooled solution of Trf<sub>2</sub>O and pyridine in dry DCM (Procedure 5), a solution of 5.4 g of (R)-3-Phenylacetic acid methyl ester was added. After the workup (Procedure 5), the yield was 74%. The product was used immediately or kept in a cold desiccator under Ar.

COMPOUND 13N<sup>+</sup> (Bzl) (2-Boc-amino ethylene) (R) Phenylalanine methyl ester

A solution of 6.24 g of (S)-O-Trf-3-Phenyllactic acid methyl ester in dry DCM (Compound 11) was added to a solution of 5.51 g of N-Boc, N-Bzl-diamino ethane (Compound 5) in dry DCM (Procedure 6). Yield 69.2%

( $\alpha$ )<sub>D</sub> = +64.0 (c=1, MeOH)

TLC (Method C) R<sub>f</sub> = 0.41 (one spot)

25 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 14N<sup>+</sup> (Bzl) (3-Boc-amino propylene) (S) Phenylalanine methyl ester

A solution of 6.24 g of (R)-O-Trf-3-Phenyllactic acid methyl ester in dry DCM (Compound 12) was added to a solution of 5.82 g of N-Boc, N-Bzl-diamino propane (Compound 6) in dry DCM (Procedure 6). Yield 67.7%

( $\alpha$ )<sub>D</sub> = -55.8 (c=1, MeOH)

TLC (Method C) R<sub>f</sub> = 0.38 (one spot)

COMPOUND 15N<sup>o</sup> (Bzl) (4-Boc-amino butylene) (S) Phenylalanine methyl ester

A solution of 6.24 g of O-Trf-(R)-3-Phenyllactic acid methyl ester in dry DCM (Compound 12) was add to a solution of  
5 6.12 g of N-Boc, N-Bzl-diamino butane (Compound 7) in dry DCM (Procedure 6). Yield 58.6%

$(\alpha)_D = -62.6$  (c=1, MeOH)

R<sub>f</sub> (Method C ) 0.42 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

10

COMPOUND 16N<sup>o</sup> (Bzl) (6-Boc-amino hexylene) (S) Phenylalanine methyl ester

A solution of 6.24 g of O-Trf-(R)-3-Phenyllactic acid methyl ester in dry DCM (Compound 12) was add to a solution of  
15 6.74 g of N-Boc, N-Bzl-diamino hexane (Compound 8) in dry DCM (Procedure 6). Yield 78.9%

$(\alpha)_D = -60.0$  (c=1, MeOH)

TLC (Method C) R<sub>f</sub>=0.47 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

20

COMPOUND 17N<sup>o</sup> (Bzl) (3-Boc-amino propylene) (R) Phenylalanine methyl ester

A solution of 6.24 g of O-Trf-(S)-3-Phenyllactic acid methyl ester in dry DCM (Compound 11) was add to a solution of  
25 5.82 g of N-Boc, N-Bzl-diamino propane (Compound 6) in dry DCM (Procedure 6). Yield 51.5%

$(\alpha)_D = +58.8$  (c=1, MeOH)

TLC (Method C) R<sub>f</sub>=0.35 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

30

COMPOUND 18N<sup>o</sup> (Bzl) (4-Boc-amino butylene) (R) Phenylalanine methyl ester

A solution of 6.24 g of O-Trf-(S)-3-Phenyllactic acid methyl ester in dry DCM (Compound 11) was add to a solution of

Procedure 6 Yield 59.8%

$(\alpha)_D = +59.0$  (c=1, MeOH)

TLC (Method C)  $R_f=0.33$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 19

##### 5 $N^{\alpha}$ (Bzl) (3-Boc-amino propylene) (S) Phenylalanine

A solution of 6.61 g of  $N^{\alpha}$  (Bzl) (3-Boc-amino propylene) (S) Phenylalanine methyl ester in MeOH (Compound 14) was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 89.5%  
 $(\alpha)_D = -24.0$  ( $c=1$ , MeOH)

10 TLC (Method B)  $R_f=0.16$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 20

##### $N^{\alpha}$ (Bzl) (4-Boc-amino butylene) (S) Phenylalanine

15 A solution of 6.61 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino butylene) (S) Phenylalanine methyl ester in MeOH (Compound 15) was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 73.5%  
 $(\alpha)_D = -12.0$  ( $c=1$ , MeOH)

TLC (Method D)  $R_f=0.6$  (one spot)

20 NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 21

##### $N^{\alpha}$ (Bzl) (3-Boc-amino propylene) (R) Phenylalanine

A solution of 6.40 g of  $N^{\alpha}$  (Bzl) (3-Boc-amino propylene) (R) Phenylalanine methyl ester in MeOH (Compound 17) was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 100%  
 $(\alpha)_D = +15.33$  ( $c=1$ , MeOH)

TLC (Method B)  $R_f=0.38$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

30

#### COMPOUND 22

##### $N^{\alpha}$ (Bzl) (4-Boc-amino butylene) (R) Phenylalanine

A solution of 6.61 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino butylene) (R) Phenylalanine methyl ester in MeOH (Compound 18) was

TLC (Method D)  $R_f=0.54$  (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 23

N<sup>o</sup> (3-Boc-amino propylene) (S) Phenylalanine HCl

- 5 A solution of 5.39 g of N<sup>o</sup> (Bzl) (3-Boc-amino propylene)  
(S) Phenylalanine (Compound 19) in MeOH-DMF was hydrogenated on  
Pd/C (Procedure 8). Yield 86.1%  
TLC (Method A) R<sub>f</sub> = 0.51 (one spot)  
NMR (D<sub>2</sub>O+Na<sub>2</sub>CO<sub>3</sub>) in agreement with the title compound.

10

COMPOUND 24

N<sup>o</sup> (4-Boc-amino butylene) (S) Phenylalanine HCl

- A solution of 5.56 g of N<sup>o</sup> (Bzl) (4-Boc-amino butylene)  
(S) Phenylalanine (Compound 20) in MeOH-DMF was hydrogenated on  
15 Pd/C (Procedure 8). Yield 79.25%  
TLC (Method A) R<sub>f</sub> = 0.50 (one spot)  
NMR (D<sub>2</sub>O+Na<sub>2</sub>CO<sub>3</sub>) in agreement with the title compound.

COMPOUND 25

20 N<sup>o</sup> (3-Boc-amino propylene) (R) Phenylalanine HCl

- A solution of 5.39 g of N<sup>o</sup> (Bzl) (3-Boc-amino propylene)  
(R) Phenylalanine (Compound 21) in MeOH-DMF was hydrogenated on  
Pd/C (Procedure 8). Yield 75.5%  
TLC (Method A) R<sub>f</sub> = 0.51 (one spot)  
25 NMR (D<sub>2</sub>O+Na<sub>2</sub>CO<sub>3</sub>) in agreement with the title compound.

COMPOUND 26

N<sup>o</sup> (4-Boc-amino butylene) (R) Phenylalanine HCl

- A solution of 5.56 g of N<sup>o</sup> (Bzl) (4-Boc-amino butylene)  
30 (R) Phenylalanine (Compound 22) in MeOH-DMF was hydrogenated on  
Pd/C (Procedure 8). Yield 73.85%  
TLC (Method A) R<sub>f</sub> = 0.50 (one spot)  
NMR (D<sub>2</sub>O+Na<sub>2</sub>CO<sub>3</sub>) in agreement with the title compound.

EXAMPLE 1

COMPOUND 1 N<sup>o</sup> (3-Boc-amino propylene) (S) Phenylalanine

A solution of 2.51 g of N<sup>o</sup> (3-Boc-amino propylene) (S) Phenylalanine.HCl (Compound 23) in H<sub>2</sub>O-ACN was reacted with FmocOSu (Procedure 9). Yield 64.84%  
TLC (Method D) R<sub>f</sub> = 0.74 (one spot)  
5 (α)<sub>D</sub> = -87 (c=1, MeOH)  
HPLC (Method G) 92 %  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

EXAMPLE 6:

10 COMPOUND 28: N<sup>o</sup>(Fmoc) (3-Boc-amino propylene) (R) Phenylalanine

A solution of 2.51 g of N<sup>o</sup> (3-Boc-amino propylene) (R) Phenylalanine.HCl (Compound 25) in H<sub>2</sub>O-ACN was reacted with FmocOSu (Procedure 9). Yield 61.56%  
TLC (Method D) R<sub>f</sub> = 0.62 (one spot)  
15 (α)<sub>D</sub> = +79.6 (c=1, MeOH)  
HPLC (Method G) 94 %  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

EXAMPLE 7:

20 COMPOUND 29: N<sup>o</sup>(Fmoc) (4-Boc-amino butylene) (S) Phenylalanine

A solution of 2.61 g of N<sup>o</sup> (4-Boc-amino butylene) (S) Phenylalanine.HCl (Compound 24) in H<sub>2</sub>O-ACN was reacted with FmocOSu (Procedure 9). Yield 56%  
TLC (Method D) R<sub>f</sub> = 0.64 (one spot)  
25 HPLC (Method G) 89 %  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 30

O-Trf-(S)-Lactic acid methyl ester

30 To a cooled solution of Trf<sub>2</sub>O and pyridine in DCM (Procedure 5), a solution of 2.9 mL of (S)lactic acid methyl ester was added. After the workup (Procedure 5), the yield was 70%. The product was used immediately or kept in a cold desiccator under N<sub>2</sub>.

COMPOUND 31

O-Trf-(R)-Lactic acid methyl ester

To a cooled solution of Trf<sub>2</sub>O and pyridine in DCM (Procedure 5), a solution of 2.9 mL of (R) lactic acid methyl ester was added. After the workup (Procedure 5), the yield was 70%. The product was used immediately or kept in a cold desiccator under Ar.

COMPOUND 32

N<sup>o</sup> (Bzl) (3-Boc-amino propylene) (S)Alanine methyl ester

A solution of 4.72 g of O-Trf-(R)-lactic acid methyl ester in dry DCM (Compound 31) was add to a solution of 5.82 g of N-Boc, N-Bzl-diamino propane (Compound 6) in dry DCM (Procedure 6). Yield 69.5 %

( $\alpha$ )<sub>D</sub> = -6.6 (C=1, MeOH)

TLC (Method C) R<sub>f</sub> = 0.42 (one spot)

15 TLC (Method D) R<sub>f</sub> = 0.92 (one spot)

TLC (Method E) R<sub>f</sub> = 0.13 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 33

20 N<sup>o</sup> (Bzl) (3-Boc-amino propylene) (R)Alanine methyl ester

A solution of 4.72 g of O-Trf-(S)-lactic acid methyl ester in dry DCM (Compound 30) was add to a solution of 5.82 g of N-Boc, N-Bzl-diamino propane (Compound 6) in dry DCM (Procedure 6). Yield 71 %

25 ( $\alpha$ )<sub>D</sub> = +6.53 (C=1, MeOH)

TLC (Method C) R<sub>f</sub> = 0.42 (one spot)

TLC (Method D) R<sub>f</sub> = 0.93 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

30 COMPOUND 34

N<sup>o</sup> (Bzl) (6-Boc-amino hexylene) (S)Alanine methyl ester

A solution of 4.72 g of O-Trf-(R)-lactic acid methyl ester in dry DCM (Compound 31) was add to a solution of 6.74 g of N-Boc, N-Bzl-diamino hexane (Compound 8) in dry DCM (Procedure 6). Yield 71 %

( $\alpha$ )<sub>D</sub> = -6.6 (C=1, MeOH)

TLC (Method D) R<sub>f</sub> = 0.95 (one spot)

TLC (Method E)  $R_f = 0.26$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

COMPOUND 35

5  $N^*$  (Bzl) (2-Boc-amino propylene) (S)Alanine

A solution of 5.25 g of  $N^*$  (Bzl) (2-Boc-amino ethylene) (S)Alanine methyl ester in MeOH (Compound 32) was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 100 % of white solid, mp  $64^\circ C$

10  $(\alpha)_D = +0.5$  (C=1, MeOH)

TLC (Method A)  $R_f = 0.64$  (one spot)

TLC (Method D)  $R_f = 0.47$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

15 COMPOUND 36

$N^*$  (Bzl) (6-Boc-amino hexylene) (S)Alanine

A solution of 5.88 g of  $N^*$  (Bzl) (6-Boc-amino hexylene) (S)Alanine methyl ester (Compound 34) in MeOH was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 100 %

20  $(\alpha)_D = +0.7$  (C=1, MeOH)

TLC (Method D)  $R_f = 0.51$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

COMPOUND 37

25  $N^*$  (Bzl) (3-Boc-amino propylene) (R)Alanine

A solution of 5.25 g of  $N^*$  (Bzl) (2-Boc-amino ethylene) (R)Alanine methyl ester (Compound 35) in MeOH was hydrolyzed by NaOH 7.5N (Procedure 7). Yield 100 %

$(\alpha)_D = -0.5$  (C=1, MeOH)

30 TLC (Method D)  $R_f = 0.51$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

COMPOUND 38

$N^*$  (3-Boc-amino propylene) (S)Alanine.HCl

Procedure 7. Yield 75 %

TLC (Method A)  $R_f = 0.42$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 39

##### 5 $N^{\alpha}$ (6-Boc-amino hexylene) (S)Alanine .HCl

A solution of 5 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino hexylene) (S)Alanine (Compound 36) in MeOH-DMF was hydrogenated on Pd/C (Procedure 8). Yield 64.5 % of white solid, mp 134-136 °C

TLC (Method A)  $R_f = 0.39$  (one spot)

10 NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 40

##### $N^{\alpha}$ (3-Boc-amino propylene) (R)Alanine .HCl

A solution of 5 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino propylene) (R)Alanine (Compound 37) in MeOH-DMF was hydrogenated on Pd/C (Procedure 8). Yield 79.1 %.

TLC (Method A)  $R_f = 0.39$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

#### 20 EXAMPLE 8:

##### COMPOUND 41: $N^{\alpha}$ (Fmoc) (3-Boc-amino propylene) (S)Alanine

A solution of 2.82 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino propylene) (S)Alanine .HCl (Compound 38) in  $H_2O$ -ACN was reacted with FmocOSu (Procedure 9). Yield 75 % of white solid, mp 70-72 °C

25 TLC (Method D)  $R_f = 0.65$  (one spot)

NMR ( $CDCl_3$ ) in agreement with the title compound.

Elemental Analysis:	% C	% H	% N
Found:	66.40	6.78	5.63
Calc:	66.65	6.88	5.93

30

#### EXAMPLE 9:

##### COMPOUND 42: $N^{\alpha}$ (Fmoc) (6-Boc-amino hexylene) (S)Alanine

A solution of 3.25 g of  $N^{\alpha}$  (Bzl) (4-Boc-amino hexylene) (S)Alanine .HCl (Compound 39) in  $H_2O$ -ACN was reacted with

35 FmocOSu (Procedure 9). Yield 75 % of white solid, mp 70-72 °C

TLC (Method D)  $R_f = 0.65$  (one spot)



NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental Analysis:	% C	% H	% N
Found:	68.37	7.40	5.23
Calc:	68.21	7.50	5.49

5 HPLC (Method G) 90%

**EXAMPLE 10:**

COMPOUND 43: N<sup>2</sup>(Fmoc)(3-Boc-amino propylene)(R)Alanine

A solution of 2.82 g of N<sup>2</sup>(Bzl)(4-Boc-amino propylene)

10 (S)Alanine .HCl (Compound 40) in H<sub>2</sub>O-ACN was reacted with FmocOSu (Procedure 9). Yield 75.9 % of white solid, mp 70-72°C

TLC (Method D) R<sub>f</sub> = 0.5 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

15 Elemental Analysis:	% C	% H	% N
Found:	66.4	6.78	5.63
Calc:	66.65	6.88	5.93

**EXAMPLE 11:**

20 COMPOUND 44: N-(2-(benzylthio)ethylene)glycine ethyl ester

The title compound was prepared according to procedure 13 from ethyl bromo acetate.

Yield 75% of colorless oil.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

25 Elemental analysis-calculated: C-61.16, H-7.70, N-3.96 ;  
found: C-61.45, H-8.03, N-3.49.

COMPOUND 45

N-(3-(benzylthio)propylene)glycine methyl ester

30 The title compound was prepared according to procedure 13 from methyl bromo acetate.

Yield 74% of colorless oil.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 46

N-(3-(benzylthio)propylene)glycine methyl ester

The title compound was prepared according to procedure 13 from the Triflate of (R) leucine methyl ester (Procedure 5).

Yield 70% of colorless oil.

5 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis-calculated: C-65.05, H-8.53, N-4.74 ;

found: C-66.29, H-9.03, N-4.49.

(a)<sub>D14</sub> = -51.2° (C 0.94, DCM).

10 EXAMPLE 13:

COMPOUND 47: N-(3-(benzylthio)propylene) (S)leucine methyl ester

The title compound was prepared according to procedure 13 from the Triflate of (R)leucine methyl ester (Procedure 5).

15 Yield 60% of colorless oil.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis- calculated: C-65.98, H-8.79, N-4.53 ;

found: C-67.09, H-9.20, N-4.54.

(a)<sub>D23</sub> = -17.4° (C 1.44, DCM).

20

COMPOUND 48:

N-(2-(benzylthio)ethylene) (S)phenylalanine methyl ester

The title compound was prepared according to procedure 13 from the Triflate of (R)phenyl lactic acid methyl ester

25 (Procedure 5).

Yield 82% of white crystals.

m.p. = 48-49°C.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis- calculated: C-69.27, H-7.04, N-4.25 ;

30 found: C-69.55, H-7.21, N-4.08.

(a)<sub>D14</sub> = -23.3° (C = 1.01, DCM).

COMPOUND 49

N-(3-(benzylthio)propylene) (S)phenylalanine methyl ester

Yield 71% of white crystals.

m.p.=38-39°C.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis- calculated: C-69.94, H-7.34, N-4.08 ;

5 found: C-69.66, H-7.39,

N-4.37.

(a)<sub>D26</sub>=+2.0° (C 1.00, DCM).

#### COMPOUND 50

#### 10 N-(4-(benzylthio)butylene)(S)phenylalanine methyl ester

The title compound was prepared according to procedure 13 from the Triflate of (S)phenyl lactic acid methyl ester (Procedure 5).

Yield 81% of colorless oil.

15 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis- calculated: C-70.55, H-7.61, N-3.92 ;

found: C-70.51, H-7.69,

N-4.22.

(a)<sub>D26</sub>=+4.9° (C 1.00, DCM).

20

#### EXAMPLE 14:

#### COMPOUND 51: Boc-N-(2-(benzylthio)ethylene)glycine

The title compound was prepared from Compound 44 by hydrolysis according to Procedure 11.

25 Yield 88% of white crystals.

m.p.=71-72°C.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental analysis- calculated: C-59.05, H-7.12, N-4.30 ;

found: C-59.39, H-7.26, N-4.18.

30

#### EXAMPLE 15:

#### COMPOUND 52: Boc-N-(2-(benzylthio)ethylene)(S)phenylalanine

The title compound was prepared from Compound 48 by hydrolysis according to Procedure 11.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

(a)<sub>D25</sub> = -105.9° (C 1.01, DCM).

EXAMPLE 16:

COMPOUND 53: Boc-N-(3-(benzylthio)propylene)(S)phenylalanine

5 The title compound was prepared from Compound 49 by hydrolysis according to Procedure 11.

Yield 99% of white crystals.

m.p. = 63-64°C.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

10 (a)<sub>D25</sub> = -87.4° (C 1.01, DCM).

EXAMPLE 17:

COMPOUND 54: Boc-L-phenylalanyl-N-(2-(benzylthio)-ethylene)glycine ethyl ester

15 Boc-L-Phe was coupled to N-(2-(benzylthio)-ethylene)glycine ethyl ester (Compound 44) according to Procedure 12.

Yield 32% of colorless oil.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

20 Elemental analysis- calculated: C-64.77, H-7.25, N-5.60 ;  
found: C-64.39, H-7.02, N-5.53.

(a)<sub>D16</sub> = +4.5° (C 0.88, DCM).

EXAMPLE 18:

25 COMPOUND 55: Boc-L-phenylalanyl-N-(2-(benzylthio)-ethylene)(S)phenylalanine methyl ester

Boc-L-Phe was coupled to N-(2-(benzylthio)ethylene)(S)phenylalanine methyl ester (Compound 48) according to Procedure 12.

30 Yield 46% of colorless oil.

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

(a)<sub>D26</sub> = -115.9° (C 1.0, CHCl<sub>3</sub>).

COMPOUND 56

A solution of 6.16 g of  $\beta$ - alanine t-butyl ester acetate in 150 mL water was reacted with benzaldehyde (Procedure 2) to give 4.5 g, 64.5% yield  
TLC (Method A)  $R_f$ =0.78 (one spot)  
5 NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 57

##### N-Bzl- $\gamma$ - amino butyric acid t-butyl ester

A solution of 6.58 g of  $\gamma$ - aminobutyric acid t-butyl ester acetate in 150 mL water was reacted with benzaldehyde (Procedure 2) to give 4.24 g, 57.9% yield  
TLC (Method A)  $R_f$ =0.74 (one spot)  
NMR ( $CDCl_3$ ) in agreement with the title compound.

#### 15 COMPOUND 58

##### N<sup>o</sup> (Bzl) (2-t-butyl carboxy ethylene)glycine benzyl ester

A solution of 3.53 g of N-Bzl- $\beta$ - alanine t-butyl ester (Compound 56) in DMF was reacted with 2.61 mL benzyl bromoacetate (Procedure 17). Yield 86.9%  
20 TLC (Method F)  $R_f$ =0.95 (one spot)  
NMR ( $CDCl_3$ ) in agreement with the title compound.

#### COMPOUND 59

##### N<sup>o</sup> (Bzl) (3-t-butyl carboxy propylene)glycine benzyl ester

25 A solution of 3.53 g of N-Bzl- $\gamma$ - aminobutyric acid t-butyl ester (Compound 57) in DMF was reacted with 2.61 mL benzyl bromoacetate (Procedure 17). Yield 83%  
TLC (Method F)  $R_f$ =0.92 (one spot)  
NMR ( $CDCl_3$ ) in agreement with the title compound.

30

#### COMPOUND 60

##### N<sup>o</sup> (2-t-butyl carboxy ethylene)glycine

A solution of N<sup>o</sup> (Bzl) (2-t-butyl carboxy ethylene)glycine benzyl ester (Compound 58) in  $CH_2Cl_2$  was reacted with 2.61 mL benzyl bromoacetate (Procedure 17). Yield 86.9%  
TLC (Method F)  $R_f$ =0.95 (one spot)  
NMR ( $CDCl_3$ ) in agreement with the title compound.

NMR ( $CDCl_3$ ) in agreement with the title compound.

COMPOUND 61N<sup>α</sup> (3-t-butyl carboxy propylene)glycine

A solution of N<sup>α</sup> (Bzl) (3-t-butyl carboxy propylene)glycine benzyl ester (Compound 59) in MeOH was hydrogenated (Procedure 8). Yield 94%  
 TLC (Method A) Rf=0.3 (one spot)  
 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

EXAMPLE 19: COMPOUND 6210 N<sup>α</sup> (Fmoc) (2-t-butyl carboxy ethylene)glycine

A solution of N<sup>α</sup> (2-t-butyl carboxy ethylene)glycine (Compound 60) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 90%  
 TLC (Method D) Rf=0.5 (one spot)  
 15 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental Analysis:	% C	% H	% N
Found:	67.38	6.34	3.11
Calc:	67.75	6.40	3.29

20 EXAMPLE 20:COMPOUND 63: N<sup>α</sup> (Fmoc) (3-t-butyl carboxy propylene)glycine

A solution of N<sup>α</sup> (3-t-butyl carboxy propylene)glycine (Compound 61) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 82%  
 25 TLC (Method D) Rf=0.58 (one spot)  
 NMR (CDCl<sub>3</sub>) in agreement with the title compound.  
 Elemental Analysis:    % C        % H        % N  
                          Found:        68.29    6.83        3.88  
                          Calc:        68.32    6.65        3.19

30

COMPOUND 64(R)-O-Trf-3-Phenyllactic acid benzyl ester

To a cooled solution of Trf<sub>2</sub>O and pyridine in dry DCM (Procedure 5) a solution of 5.3 g of (R)-3-Phenyllactic acid was added.  
 a cold desiccator under Ar.

COMPOUND 65

N<sup>α</sup>(Bzl)(2-t-butyl carboxy ethylene)(S) Phenylalanine benzyl ester

- A solution of 5.48 g of N-Bzl-β- alanine t-butyl ester  
 5 (Compound 56) in DCM was reacted with 7.35 g of (R)-O-Trf-3-  
 Phenyllactic acid benzyl ester (COMPOUND 64) in dry DCM  
 (Procedure 6). After workup the crude product was purified by  
 flash chromatography. PE:EtOAc (4:1) 1.5 L. After solvent  
 evaporation under vacuum, the product was dried under vacuum.  
 10 Yield 71.5%  
 TLC (Method C) Rf=0.77 (one spot)  
 (α)<sub>D</sub> = -62.7 (C=1, MeOH)  
 NMR (CDCl<sub>3</sub>) in agreement with the title compound:

15 COMPOUND 66

N<sup>α</sup>(2-t-butyl carboxy ethylene)(S) Phenylalanine

- A solution of 6.3 g of N<sup>α</sup>(Bzl)(2-t-butyl carboxy  
 ethylene)(S) Phenylalanine benzyl ester (Compound 65) in MeOH  
 was hydrogenated (Procedure 8). Yield 48.6%  
 20 TLC (Method A) Rf=0.52-0.54 (one spot)  
 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

EXAMPLE 21:

COMPOUND 67: N<sup>α</sup>(Fmoc)(2-t-butyl carboxy ethylene)(S)

25 Phenylalanine

- A solution of 2.13 g of N<sup>α</sup>(2-t-butyl carboxy  
 ethylene)(S) Phenylalanine (Compound 66) in H<sub>2</sub>O:Et<sub>3</sub>N was  
 reacted with FmocOSu (Procedure 9). Yield 38%  
 TLC (Method D) Rf=0.77 (one spot)  
 30 NMR (CDCl<sub>3</sub>) in agreement with the title compound.  
 Elemental Analysis:    % C        % H        % N  
                          Found:        71.92    6.39        2.87  
                          Calc:        72.21    6.45        2.72  
 HPLC (Method G) 93%

11. Example 22: N<sup>α</sup>(Fmoc)(2-t-butyl carboxy ethylene)(S) Phenylalanine

A solution of 0.0325 mole of N-Boc, N-Bzl,1,2  
diaminoethane (Compound 5) in DMF was reacted with 5.15 mL  
benzyl bromoacetate (Procedure 17). Yield 97.9%  
TLC (Method F) Rf=0.78 (one spot)  
5 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 69

N<sup>o</sup> (Bzl) (3-Boc amino propylene)glycine benzyl ester

A solution of 0.0325 mole of N-Boc, N-Bzl,1,3  
10 diaminopropane (Compound 6) in DMF was reacted with 5.15 mL  
benzyl bromoacetate (Procedure 17). Yield 98.2%  
TLC (Method F) Rf=0.78 (one spot)  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

15 COMPOUND 70

N<sup>o</sup> (Bzl) (4-Boc amino butylene)glycine benzyl ester

A solution of 0.0325 mole of N-Boc, N-Bzl,1,4  
diaminobutane (Compound 7) in DMF was reacted with 5.15 mL  
benzyl bromoacetate (Procedure 17). Yield 98.8%  
20 TLC (Method F) Rf=0.82 (one spot)  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 71

N<sup>o</sup> (Bzl) (6-Boc amino hexylene)glycine benzyl ester

A solution of 0.0325 mole of N-Boc, N-Bzl,1,6  
25 diaminohexane (Compound 8) in DMF was reacted with 5.15 mL  
benzyl bromoacetate (Procedure 17). Yield 98.8%  
TLC (Method F) Rf=0.79 (one spot)  
NMR (CDCl<sub>3</sub>) in agreement with the title compound.

30

COMPOUND 72

N<sup>o</sup> (2-Boc amino ethylene)glycine

A solution of 0.025 mole of N<sup>o</sup> (Bzl) (2-Boc amino  
ethylene)glycine benzyl ester (Compound 68) in 60 mL MeOH was



NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 73

N<sup>α</sup>(3-Boc amino propylene)glycine

5 A solution of 0.025 mole of N<sup>α</sup> (Bzl) (3-Boc amino propylene)glycine benzyl ester (Compound 69) in 60 mL MeOH was hydrogenated (Procedure 8). Yield 74% of white solid. mp 214-6 °C.

TLC (Method A) Rf=0.27 (one spot)

10 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

COMPOUND 74

N<sup>α</sup>(4-Boc amino butylene)glycine

A solution of 0.025 mole of N<sup>α</sup> (Bzl) (4-Boc amino butylene)glycine benzyl ester (Compound 70) in 60 mL MeOH was hydrogenated (Procedure 8). Yield 89.5% of white solid. mp 176-8 °C.

TLC (Method A) Rf=0.23 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

20

COMPOUND 75

N<sup>α</sup>(6-Boc amino hexylene)glycine

A solution of 0.025 mole of N<sup>α</sup> (Bzl) (6-Boc amino hexylene)glycine benzyl ester (Compound 71) in 60 mL MeOH was hydrogenated (Procedure 8). Yield 80% of white solid. mp 172- 4°C.

TLC (Method A) Rf=0.26 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

30 EXAMPLE 22:

COMPOUND 76: N<sup>α</sup>(Fmoc) (2-Boc amino ethylene)glycine

A solution of 0.02 mole of N<sup>α</sup> (2-Boc amino ethylene)glycine (Compound 72) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 80% of white solid. mp 130-132

elemental analysis. C, H, N, O

Found:	65.18	6.11	5.91
Calc:	65.43	6.40	6.63

EXAMPLE 23:5 COMPOUND 77: N<sup>o</sup>(Fmoc) (3-Boc amino propylene)glycine

A solution of 0.02 mole of N<sup>o</sup>(Fmoc) (3-Boc amino propylene)glycine (Compound 73) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 85% of white solid. mp 125°C. TLC (Method D) R<sub>f</sub>=0.5-0.6 (one spot)

10 NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental Analysis:	% C	% H	% N
Found:	66.05	6.65	6.00
Calc:	66.06	6.65	6.16

15

EXAMPLE 24:COMPOUND 78: N<sup>o</sup>(Fmoc) (4-Boc amino butylene)glycine

A solution of 0.02 mole of N<sup>o</sup>(Fmoc) (4-Boc amino butylene)glycine (Compound 74) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 79.4% of white solid. mp 150 - 152 °C.

TLC (Method D) R<sub>f</sub>=0.42-0.47 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

Elemental Analysis:	% C	% H	% N
25 Found:	66.35	6.84	5.77
Calc:	66.06	6.88	5.98

EXAMPLE 25:COMPOUND 79: N<sup>o</sup>(Fmoc) (6-Boc amino hexylene)glycine

30 A solution of 0.02 mole of N<sup>o</sup>(Fmoc) (6-Boc amino hexylene)glycine (Compound 75) in H<sub>2</sub>O:Et<sub>3</sub>N was reacted with FmocOSu (Procedure 9). Yield 81.5% of white solid. mp 78-80 °C. TLC (Method D) R<sub>f</sub>=0.7 (one spot)

NMR (CDCl<sub>3</sub>) in agreement with the title compound.

### SYNTHETIC EXAMPLES

Two series of octapeptide somatostatin analogs of the present invention were synthesized, characterized, and tested for biological activity.

1) The first series of compounds corresponds to the general Formula (XIVb); this series comprises compounds of the specific formula

10                   H- (D)Phe-R<sup>6</sup>-Phe- (D)Trp-Lys-Thr-R<sup>11</sup>-Thr-NH<sub>2</sub>  
wherein R<sup>6</sup> and R<sup>11</sup> are N<sup>α</sup> ω-functionalized alkylene amino acid building units.

2) The second series of compounds corresponds to the general Formula (XVIc); this series comprises compounds of the specific formula

                  H- (D)Phe-R<sup>6</sup>-Phe- (D)Trp-Lys-R<sup>10</sup>-Thr-NH<sub>2</sub>  
wherein R<sup>6</sup> and R<sup>10</sup> are N<sup>α</sup> ω-functionalized alkylene amino acid building units.

The structures of these novel synthetic peptide analogs into which N<sup>α</sup> ω-functionalized amino acid building units were incorporated, are summarized in Tables 7 and 8. In both series, the building units used were glycine building units in which the bridging groups, attached via the alpha nitrogens to the peptide backbone, were varied.

25           For the sake of simplicity, these two series are referred to herein as the SST Gly<sup>6</sup>,Gly<sup>11</sup> and SST Gly<sup>6</sup>,Gly<sup>10</sup> series, respectively.

In each series, the position of the cyclization points was constant, while the length and direction of the bridge was varied. Thus, C2,N2 refers to a bridge consisting of an amide bond in which the carbonyl group is closer to the amino end of the peptide and which contains two methylene groups between the bridge amide and each of the backbone nitrogens involved in the bridge.

After synthesis, following peptide assembly, de-protection of

bridging groups that form the cyclization arms was carried out with  $\text{Pd}(\text{PPh}_3)_4$  (palladium tetrakis triphenyl phosphine) in the case of Allyl/Alloc protecting groups or with TFA in the case of tBu/Boc protecting groups. For obtaining the linear (non-cyclized) analog, the peptides were cleaved from the resin at this stage. Cyclization of the peptides was carried out with PyBOP. Cleavage of the peptides from the polymeric support was carried out with suitable reagents depending on the type of resin used, e.g., with TFA for Rink amide type resins and with HF for MBHA (para-methyl benzhydryl amine) type resins. The crude products were characterized by analytical HPLC. The peptides were purified by preparative reversed phase HPLC. The purified products were characterized by analytical HPLC, mass spectroscopy, and amino acid analysis.

15

Table 7  
SST Gly<sup>6</sup>, Gly<sup>11</sup>

	Example No.	Bridging Groups	Compound Number	Method	Crude Yield
20	26	C1,N2 Cyclic	DE-3-32-4	1	NA**
	27	C1,N2 Linear <sup>*</sup>	DE-3-32-2	1	NA
	28	C1,N3 Cyclic	PTR 3004	2	79 mg
	29	C1,N3 Linear	PTR 3005	2	34 mg
25	30	C2,N2 Cyclic	PTR 3002	1	NA
	31	C2,N2 Linear	PTR 3001	1	NA
	32	C2,N3 Cyclic	PTR 3007	2	40 mg
	33	C2,N3 Linear	PTR 3008	2	40 mg
30	34	N2,C2 Cyclic	YD-9-166-1	2	NA
	35	N2,C2 Linear	YD-9-168-1	2	NA
	36	N3,C2 Cyclic	PTR 3010	2	100 mg
	37	N3,C2 Linear	PTR 3011	2	NA
	38	Linear*	PTR 3003	3	96 mg

\* Linear refers to the identical sequence with Gly residues in place of P<sup>6</sup> and P<sup>11</sup>

- 2) Manual synthesis on Rapp tentagel resin. TFA cleavage.
- 3) Rink amide resin; assembly in automated peptide synthesizer, 0.1 mmol scale.

Table 8  
SST Gly<sup>6</sup>, Gly<sup>10</sup>

Example No.	Bridging Groups	Compound Number	Method	Crude Yield
39	C1,N2 Cyclic	YD-9-171-3	1	20 mg
40	C1,N2 Linear	YD-9-171-2	1	10 mg
41	C1,N3 Cyclic	YD-9-175-3	1	44.9 mg
42	C1,N3 Linear	YD-9-175-2	1	25.4 mg
43	C2,N2 Cyclic	PTR 3019	1	40 mg
44	C2,N2 Linear	PTR 3020	1	26 mg
45	C2,N3 Cyclic	YD-5-28-3	3	101.5 mg
46	C2,N3 Linear	YD-5-28-2	3	48.3 mg
47	N2,C2 Cyclic	PTR 3016	2	60 mg
48	N2,C2 Linear	PTR 3017	2	40 mg
49	N3,C2 Cyclic	YS-8-153-1	2	93 mg
50	N3,C2 Linear	YS-8-152-1	2	54 mg
51	* Linear	PTR 3021	1	100 mg
	** Acetylated Des-D-Phe <sup>5</sup>			
52	N3,C2 Cyclic	PTR 3013		67 mg
53	N3,C2 Linear	PTR 3014		48 mg

\* Linear refers to the identical sequence with Gly residues in place of R<sup>6</sup> and R<sup>10</sup>.

\*\* Acetylated Des-D-Phe<sup>5</sup> refers to the same sequence in which the N terminal D-Phe<sup>5</sup> is absent and the N-terminus is acetylated.

30

Table 8 methods:

- 1) Assembly in automated peptide synthesizer; 0.1 mmol scale. (HBTU).
- 2) Manual synthesis; PyBrop.
- 3) Assembly in automated peptide synthesizer, 0.25 mmol scale. (HBTU).

Synthesis of SST Gly<sup>6</sup>, Gly<sup>10</sup> N3, C2:

Five grams of Rink amide resin (NOVA) (0.49 mmol/g), were swelled in N-methylpyrrolidone (NMP) in a reaction vessel equipped with a sintered glass bottom and placed on a shaker. The Fmoc protecting group was removed from the resin by reaction with 20% piperidine in NMP (2 times 10 minutes, 25 ml each). Fmoc removal was monitored by ultraviolet absorption measurement at 290 nm. A coupling cycle was carried out with Fmoc-Thr(OtBu)-OH (3 equivalents) PyBrop (3 equivalents) DIEA (6 equivalents) in NMP (20 ml) for 2 hours at room temperature. Reaction completion was monitored by the qualitative ninhydrin test (Kaiser test). Following coupling, the peptide-resin was washed with NMP (7 times with 25 ml NMP, 2 minutes each). Capping was carried out by reaction of the peptide-resin with acetic anhydride (capping mixture: HOBt 400 mg, NMP 20 ml, acetic anhydride 10 ml, DIEA 4.4 ml) for 0.5 hours at room temperature. After capping, NMP washes were carried out as above (7 times, 2 minutes each). Fmoc removal was carried out as above. Fmoc-Phe-OH was coupled in the same manner, and the Fmoc group removed, as above. The peptide resin was reacted with Fmoc-Gly-C2 (Allyl) building unit: coupling conditions were as above. Fmoc removal was carried out as above. Fmoc-Lys(Boc)-OH was coupled to the peptide resin by reaction with HATU (3 equivalents) and DIEA (6 equivalents) at room temperature overnight and then at 50°C for one hour. Additional DIEA was added during reaction to maintain a basic medium (as determined by pH paper to be about 9). This coupling was repeated. Coupling completion was monitored by the Fmoc test (a sample of the peptide resin was taken and weighed, the Fmoc was removed as above, and the ultraviolet absorption was measured). Fmoc-D-Trp-OH was coupled to the peptide resin with PyBrop, as described above. Following Fmoc removal, Fmoc-Phe-OH was coupled in the same

Following Fmoc removal, the second building unit was introduced: Fmoc-Gly-N<sub>3</sub>(Alloc)-OH by reaction with PYBrop, as described above. Capping was carried out as described above. Following Fmoc removal, the peptide-resin was divided into two 5 equal portions. Synthesis was continued with one of these portions. Boc-D-Phe-OH was coupled by reaction with HATU, as described above for Fmoc-Lys(Boc)-OH. Capping was carried out as above.

The Allyl and Alloc protecting groups were removed by 10 reaction with Pd(PPh<sub>3</sub>)<sub>4</sub> and acetic acid 5%, morpholine 2.5% in chloroform, under argon, for 2 hours at room temperature. The peptide resin was washed with NMP as above. Two-thirds of the resin were taken for cyclization. Cyclization was carried out with PyBOP 3 equivalents, DIEA 6 equivalents, in NMP, at room 15 temperature overnight. The peptide resin was washed and dried. The peptide was cleaved from the resin by reaction with TFA 81.5%, phenol 5%, water 5%, EDT 2.5%, TIS (tri-isopropyl-silane) 1%, and 5% methylene chloride, at 0°C for 15 20 minutes and 2 hours at room temperature under argon. The mixture was filtered into cold ether (30 ml, 0°C) and the resin was washed with a small volume of TFA. The filtrate was placed in a rotary evaporator and all the volatile components were removed. An oily product was obtained. It was trituated with ether and the ether decanted, three times. A 25 white powder was obtained. This crude product was dried. The weight of the crude product was 93 mg.

#### PHYSIOLOGICAL EXAMPLES

##### 30 EXAMPLE 54: BRADYKININ ANTAGONIST ASSAY (Displacement of (<sup>3</sup>H)dopamine release from PC 12 cells)

Novel backbone cyclized peptide analogs of the present invention were assayed in vitro for bradykinin antagonist activity by protection of (<sup>3</sup>H)dopamine release from PC 12

Supplemented with 10% horse serum, 1% fetal calf serum, 100

units/ml penicillin and 0.1 mg/ml streptomycin. For experiments, cells were removed from the medium using 1 mmole EDTA and replated on collagen coated-12- well plates and assayed 24 hr later. Release of (<sup>3</sup>H)dopamine was determined as follows: cells were incubated for 1.5 hr at 37 °C with 0.5 ml of growth medium and 0.85 ml (<sup>3</sup>H)DA (41 Ci/mmol) and 10 mg/ml pargyline followed by extensive washing with medium (3X1 ml) and release buffer consisting of (mM): 130 NaCl; 5 KCl; 25 NaHCO<sub>3</sub>; 1 NaH<sub>2</sub>PO<sub>4</sub>; 10 glucose and 1.8 CaCl<sub>2</sub>. In a typical experiment, cells were incubated with 0.5 ml buffer for 5 consecutive incubation periods of 3 min each at 37 °C. Spontaneous (<sup>3</sup>H)DA release was measured by collecting the medium released by the cells successively for the first 3 min period. Antagonists were added to the cells 3 min prior to stimulation (at the second period), and stimulation of (<sup>3</sup>H)DA release by 100 nmole of bradykinin are monitored during the 3 period by 60 mmole KCl. The remaining of the (<sup>3</sup>H)DA was extracted from the cells by over night incubation with 0.5 ml 0.1 N HCl. (<sup>3</sup>H)DA release during each 3 min period was expressed as a % of the total (<sup>3</sup>H)DA content of the cells. Net evoked release was calculated from (<sup>3</sup>H)DA release during stimulation period after subtracting basal (<sup>3</sup>H)DA release in the preceding baseline period if not indicated otherwise.

At 10<sup>-6</sup> M, Example 1 showed 30 % inhibition of BK activity, Example 4 showed 17 % inhibition of BK activity. Note, the noncyclized (control) peptide of example 2 showed 0 % inhibition of BK activity.

#### EXAMPLE 55: BRADYKININ ANTAGONIST ASSAY (Guinea-pig assay)

30 The ileum of the guinea-pig was selected as the preparation for the bioassay. This tissue contains predominantly BK<sub>2</sub> receptors. The preparation consists of the longitudinal muscle layer with the adhering mesenteric plexus. The isolated preparation was kept in Krebs solution and

1. The following examples are intended to illustrate the invention and are not to be construed as limiting the scope of the invention.



measured previous to measuring the responses of backbone cyclized peptides of the present invention. Atropine (1  $\mu$ M) was always present.

At  $10^{-6}$  M, Example 1 showed 24 % inhibition of BK activity, Example 3 showed 10 % and Example 4 showed 17 % inhibition of BK activity. Note, the noncyclized (control) peptide of example 2 showed 0 % inhibition of BK activity.

**EXAMPLE 56: SOMATOSTATIN ASSAY (Receptor based screening)**

Initial screening is conducted using  $^{125}$ I-labeled SST analogs and pituitary membrane preparations or cell lines. The binding assay is described in Tran, V.T., Beal, M.F. and Martin, J.B. Science, 228:294-495, 1985, which is incorporated herein by reference in its entirety and is optimized with regards to membrane concentration, temperature and time. The assay is sensitive (nM range) and robust. Selectivity will be based on the recent cloning of the five human SST receptors. The ability to screen the compounds with regard to binding and biological activity in mammalian cells should facilitate the development of subtype-selective analogs. These compounds are useful in the treatment of specific endocrine disorders and therefore should be devoid of unwanted side effects.

**EXAMPLE 57: SOMATOSTATIN (SST) ASSAY (In vivo assays)**

The biological effects of SST on growth hormone, insulin and glucagon release is conducted by measuring the levels of these hormones using commercially available RIA test kits. Pharmacological effects of SST in patients with neuroendocrine tumors of the gut will require determination of 5-hydroxyindole acetic acid (for carcinoid) and VIP (for VIPoma). In vivo visualization of SST receptor-positive tumors is performed as described by Lambert et al., New England J. Med., 323:1246-1249 1990, following i.v. administration of radio-iodinated SST analogs.

analogues

Binding of representative peptides of Examples 39-54 to different somatostatin receptors was measured in vitro, in Chinese Hamster Ovary (CHO) cells expressing the various receptors. An example of the selectivity obtained with the cyclic peptides is presented in Table 9. The values presented are percent inhibition of radioactive iodinated somatostatin (SRIF-14) binding.

Table 9  
Binding of peptide analogs to somatostatin receptor subtypes

10			Somatostatin Receptor (SSTR) Subtype						
			SSTR.	2B			SSTR.	5	
Conc. (M)			10 <sup>-6</sup>	10 <sup>-7</sup>	10 <sup>-8</sup>		10 <sup>-6</sup>	10 <sup>-7</sup>	10 <sup>-8</sup>
15	Compound Number	Compound Description							
	PTR 3003	Linear	16	3	0		55	20	0
	PTR 3004	Cyclic C1,N3	0	0	0		14	0	0
	PTR 3005	Linear C1,N3	0	0	0		9	0	0
	PTR 3007	Cyclic C2,N3	0	0	0		19	9	0
	PTR 3008	Linear C2,N3	0	0	0		15	6	0
	PTR 3010	Cyclic N3,C2	0	0	0		63	26	9
	PTR 3011	Cyclic N3,C2	0	0	0		27	66	27
20	Control Peptides								
	BIM 3503	Pos. Control	81	33	16		92	66	27
	PTR 4003	Neg. Control	0	0	0		0	0	0

#### EXAMPLE 59: Resistance to biodegradation of SST analogs

The in vitro biostability of a SST cyclic peptide analog, PTR 3002, was measured in human serum, and was compared to the same sequence in a non-cyclic peptide analog (PTR 3001), to octreotide (Sandostatin), and to native somatostatin (SRIF). The results are shown in Figure 1. In this assay, the cyclic peptide in accordance with the present invention is as stable as octreotide, is more stable than the

EXAMPLE 60: Inhibition of growth hormone release by SST analogs

In vivo determination of the pharmacodynamic properties of cyclic peptide analogs was carried out. Inhibition of Growth Hormone (GH) release as a result of peptide administration was measured. Measurements were carried out in Sprague-Dawley male rats: peptide analog activity was compared in this study to SRIF or to octreotide (Sandostatin). Each group consisted of 4 rats. Time course profiles for GH release under constant experimental conditions were measured.

Methods

Adult male Sprague-Dawley rats, specific pathogen free (SPF), weighing 200-350 g, were maintained on a constant light-dark cycle (light from 8:00 to 20:00 h), temperature ( $21 \pm 3^\circ\text{C}$ ), and relative humidity ( $55 \pm 10\%$ ). Laboratory chow and tap water were available ad libitum. On the day of the experiment, rats were anesthetized with pentobarbitone (50 mg/kg). Rats anesthetized with pentobarbitone exhibit low somatostatin levels in portal blood vessels. (Plotsky, P.M., Science, 230, 461-463, 1985). A single blood sample (0.6 ml) was taken from the exposed cannulated jugular vein for the determination of the basal GH levels (-15 min). Immediately thereafter the appropriate peptide pretreatment was administered. The animals received 10  $\mu\text{g/kg}$  of either native somatostatin (SRIF) or the synthetic analog octreotide (Sandostatin), or the cyclic peptide analog. A saline solution (0.9% NaCl) was administered as a control. All peptides were administered subcutaneously in a final volume of 0.2 ml. Further sampling was carried out at 15, 30, 60, and 90 minutes after peptide administration. Immediately after the collection of each blood sample, an appropriate volume (0.6 ml) of saline was administered intravenously. Blood samples were collected into tubes containing heparin (15 unites per ml of blood) and centrifuged immediately. Plasma

this kit has been calibrated against a reference standard preparation (NIH-RP2) obtained from the National Institute of Diabetes and Digestive and Kidney Diseases. All samples were measured in duplicate.

5

**EXAMPLE 61: Lack of toxicity of cyclized peptide analogs**

PTR 3007 at a dose of 1.5 mg/kg was well tolerated after single intraperitoneal application. PTR 3013 was not toxic to the rats even with doses of 4 mg/kg. These two doses  
10 are several orders of magnitude higher than those needed to elicit the desired endocrine effect. The peptides dissolved in saline produced no untoward side effects on the central nervous system, cardiovascular system, body temperature, nor on the periphery of the animals. Rats were observed for 4  
15 hours post administration of the peptides. PTR 3007 and 3013 produced no respiratory disturbances, did not result in the appearance of stereotyped behavior, or produce any changes in muscle tone. After 3 hours, postmortem examination did not detect any abnormality in the liver, kidneys, arteries and  
20 veins, gastrointestinal tract, lungs, genital system, nor the spleen.

25

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THE CLAIMS

What is claimed is:

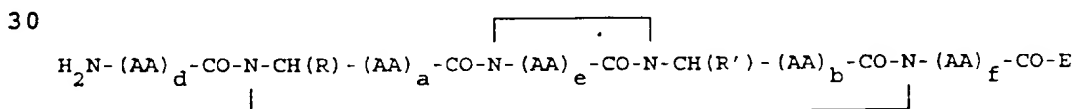
5           1. A backbone cyclized peptide analog comprising a peptide sequence that incorporates at least two building units, each of which contains one nitrogen atom of the peptide backbone connected to a bridging group comprising a disulfide, amide, thioether, thioester, imine, ether, or alkene bridge,  
10 wherein at least two of said building units are joined together to form a cyclic structure.

          2. The backbone cyclized peptide analog of claim 1 that incorporates at least four building units, each of which  
15 contains one nitrogen atom of the peptide backbone connected to the bridging groups, wherein at least two pairs of said building units are joined together to form at least two cyclic structures within said peptide sequence.

20           3. The backbone cyclized peptide analog of claim 1 wherein at least one of said building units is not located at the end of the peptide sequence.

          4. The backbone cyclized peptide analog of claim 1  
25 wherein none of said building units is located at the end of the peptide sequence.

          5. The backbone cyclized peptide analog of claim 1, having the general Formula (I):



Formula (I)

designates an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same or different; E represents a hydroxyl group, a carboxyl protecting group or an amino group, or CO-E can be reduced to CH<sub>2</sub>-OH; each of R and R' is independently hydrogen or an amino acid side-chain optionally bound with a specific protecting group; and the lines designate a bridging group of the Formula:

(i) -X-M-Y-W-Z- ; or (ii) -X-M-Z-

wherein: one line may be absent; M and W are independently selected from the group consisting of disulfide, amide, thioether, thioester, imine, ether, and alkene; and X, Y and Z are each independently selected from the group consisting of alkylene, substituted alkylene, arylene, homo- or hetero-cycloalkylene and substituted cycloalkylene.

6. The backbone cyclized peptide analog of claim 5 wherein -X-M-Y-W-Z- is:

$-(CH_2)_x-M-(CH_2)_y-W-(CH_2)_z-$

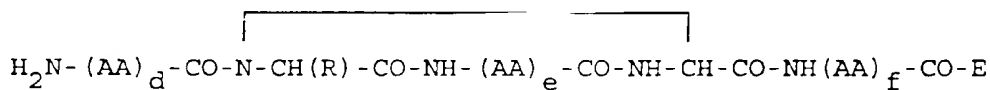
wherein M and W are independently selected from the group consisting of disulfide, amide, thioether, thioester, imine, ether, and alkene; x and z each independently designates an integer of from 1 to 10, and y is zero or an integer of from 1 to 8, with the proviso that if y is zero, W is absent.

7. The backbone cyclized peptide analog of claim 5 wherein the group CO-E is CH<sub>2</sub>OH.

8. The backbone cyclized peptide analog of claim 5 wherein R is CH<sub>3</sub>-, (CH<sub>3</sub>)<sub>2</sub>CH-, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>-, CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)-, CH<sub>3</sub>S(CH<sub>2</sub>)<sub>2</sub>-, HOCH<sub>2</sub>-, CH<sub>3</sub>CH(OH)-, HSCH<sub>2</sub>-, NH<sub>2</sub>C(=O)CH<sub>2</sub>-, NH<sub>2</sub>C(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>-, HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl,

9. The backbone cyclized peptide analog of claim 5 wherein R' is CH<sub>3</sub>, (CH<sub>3</sub>)<sub>2</sub>CH-, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>-, CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)-, CH<sub>3</sub>S(CH<sub>2</sub>)<sub>2</sub>-, HOCH<sub>2</sub>-, CH<sub>3</sub>CH(OH)-, HSCH<sub>2</sub>-, NH<sub>2</sub>C(=O)CH<sub>2</sub>-, NH<sub>2</sub>C(=O)(CH<sub>2</sub>)<sub>2</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, 5 NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, or methylimidazole.

10. A backbone cyclized peptide analog, wherein the backbone is cyclized to a side-chain of an amino acid of the 10 general Formula (II):



Formula (II)

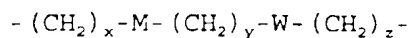
15 wherein d, e and f each independently designates an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same or different; E represents a hydroxyl group, a carboxyl 20 protecting or an amino group, or CO-E can be reduced to CH<sub>2</sub>-OH; R is an amino acid side chain optionally bound with a specific protecting group; and the line designates a bridging group of the Formula:

(i) -X-M-Y-W-Z- ; or (ii) -X-M-Z-

25 wherein M and W are independently selected from the group consisting of disulfide, amide, thioether, imine, ether, and alkene; X, Y and Z are each independently selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene.

30 11. The backbone cyclized peptide analog of claim 10 wherein R is CH<sub>3</sub>-, (CH<sub>3</sub>)<sub>2</sub>CH-, (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>-, CH<sub>3</sub>CH<sub>2</sub>CH(CH<sub>3</sub>)-, CH<sub>3</sub>S(CH<sub>2</sub>)<sub>2</sub>-, HOCH<sub>2</sub>-, CH<sub>3</sub>CH(OH)-, HSCH<sub>2</sub>-, NH<sub>2</sub>C(=O)CH<sub>2</sub>-, NH<sub>2</sub>C(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>3</sub>-, HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, 35 NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, or methylimidazole.

12. The backbone cyclized peptide analog of claim 10 wherein -X-M-Y-W-Z- is:



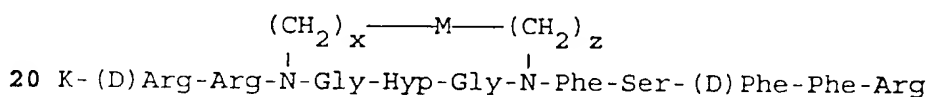
wherein M and W are independently selected from the group consisting of disulfide, amide, thioether, imine, ether, and alkene; x and z each independently designates an integer of from 1 to 10, and y is zero or an integer of from 1 to 8, with the proviso that if y is zero, W is absent.

10 13. A bradykinin analog comprising the backbone cyclized peptide analog of claim 5.

14. A bradykinin analog comprising the backbone cyclized peptide analog of claim 10.

15

15. The backbone cyclized peptide analog of claim 13 of the general Formula (III):

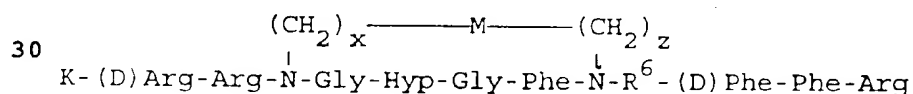


Formula (III)

wherein M is an amide bond, x and z are each independently an integer of 1 to 10, and K is H or an acyl group.

25

16. The backbone cyclized peptide analog of claim 13 of the general Formula (IVa):



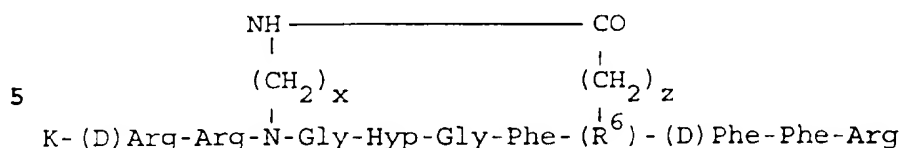
Formula (IVa)

wherein M is an amide bond, x and z are each independently an

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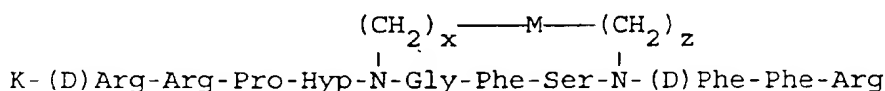
17. The backbone cyclized peptide analog of claim 14 of the general Formula (IVb):



Formula (IVb)

wherein x is an integer of 1 to 10; K is H or an acyl group;  
 10 (R<sup>6</sup>) is selected from the group of D-Asp, L-Asp, D-Glu and L-Glu; and z is 1 or 2, with the proviso that when R<sup>5</sup> is D-Asp or L-Asp, then z is 1.

18. The backbone cyclized peptide analog of claim 13  
 15 of the general Formula (V):



Formula (V)

wherein M is an amide bond, x and z are independently an integer of 1 to 10, and K is H or an acyl group.

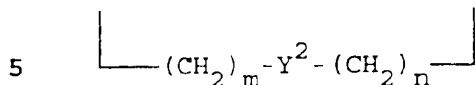
19. The backbone cyclized peptide analog of claim 13  
 25 selected from the group consisting of:

- a) Ada- (D) Arg-Arg-cyclo (N<sup>α</sup>(1- (6-aminohexylene) Gly-Hyp-Phe-D-Asp) -D-Phe-Phe-Arg-OH;
- b) H-D-Arg-Arg-cyclo (N<sup>α</sup>(1- (4-propanoyl)) Gly-Hyp-Phe-N<sup>α</sup>(3-amido-propylene) Gly) -Ser-D-Phe-Phe-Arg-OH; and
- 30 c) H-D-Arg-Arg-cyclo (N<sup>α</sup>(4-propanoyl) Gly-Hyp-Phe-N<sup>α</sup>(3-amido-propyl) -S-Phe) -Ser-D-Phe-Phe-Arg-OH.

20. A somatostatin analog comprising the backbone cyclized peptide analog of claim 5.

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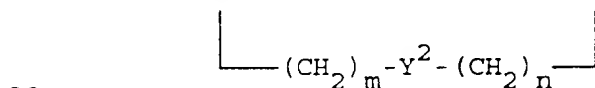
22. The backbone cyclized peptide analog of claim 20 having the general Formula (XIVa):  
 $R^5-NR^6-R^7-(D)Trp-Lys-R^{10}-NR^{11}-R^{12}-X$



Formula (XIVa)

wherein m and n are 1, 2 or 3; X is  $CH_2OH$  or  $NH_2$ ;  $R^5$  is absent or is Gly, (D)- or (L)-Ala, Phe, Nal, and  $\beta$ -Asp(Ind);  $R^6$  and  
 10  $R^{11}$  are independently Gly or (D)- or (L)-Phe;  $R^7$  is Phe or Tyr;  $R^{10}$  is absent or is Gly, Abu, Thr or Val;  $R^{12}$  is absent or is Thr or Nal; and  $Y^2$  is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

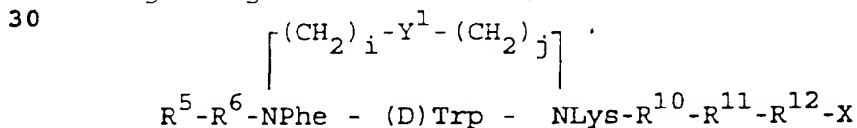
15 23. The backbone cyclized peptide analog of claim 20 having the general Formula (XIVb):  
 $H-(D)Phe-NR^6-R^7-(D)Trp-Lys-R^{10}-NR^{11}-Thr-X$



Formula (XIVb)

wherein m and n are 1, 2 or 3; X is  $CH_2OH$  or  $NH_2$ ;  $R^6$  and  $R^{11}$  are independently Gly or (D)- or (L)-Phe;  $R^7$  is Phe or Tyr;  $R^{10}$  is  
 25 absent or is Gly, Abu, Thr or Val; and  $Y^2$  is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

24. The backbone cyclized peptide analog of claim 20 having the general Formula (XVa):

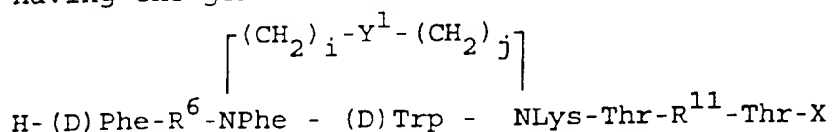


Formula (XVa)

35 wherein i and j are independently 1 or 2

is (D)- or (L)-Phe; R<sup>12</sup> is absent or is Thr or Nal, and Y<sup>1</sup> is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

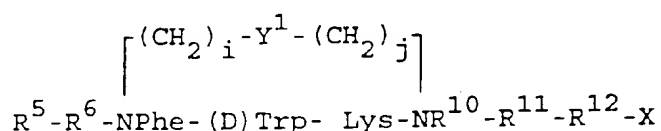
5            25. The backbone cyclized peptide analog of claim 20  
having the general Formula (XVb):



Formula (XVb)

wherein i and j are independently 1, 2 or 3; X is CH<sub>2</sub>OH or NH<sub>2</sub>; R<sup>6</sup> is (D) or (L)-Phe; R<sup>10</sup> is absent or is Gly, Abu or Thr; and R<sup>11</sup> is (D)- or (L)-Phe; R<sup>12</sup> is absent or is Thr or Nal, and  
15 Y<sup>1</sup> is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

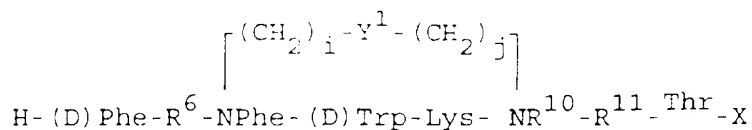
26. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIa):



Formula (XVla)

25 wherein i and j are independently 1, 2 or 3; X is CH<sub>2</sub>OH or  
NH<sub>2</sub>; R<sup>5</sup> is absent or is (D)- or (L)-Phe, Nal, or β-Asp(Ind); R<sup>6</sup>  
is (D) or (L)-Phe; R<sup>10</sup> is absent or is Gly, Abu or Thr; and R<sup>11</sup>  
is (D)- or (L)-Phe; R<sup>12</sup> is absent or is Thr or Nal, and Y<sup>1</sup> is  
30 selected from the group consisting of amide, disulfide,  
thioether, imine, ether, and alkene.

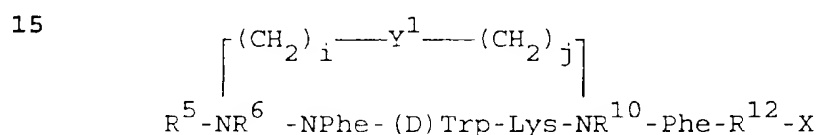
27. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIb):



5 Formula (XVIb)

wherein  $i$  and  $j$  are independently 1, 2 or 3;  $\text{X}$  is  $\text{CH}_2\text{OH}$  or  $\text{NH}_2$ ;  $\text{R}^6$  is (D) or (L)-Phe;  $\text{R}^{10}$  is absent or is Gly, Abu or Thr; and  $\text{R}^{11}$  is (D)- or (L)-Phe;  $\text{R}^{12}$  is absent or is Thr or Nal, and  
 10  $\text{Y}^1$  is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

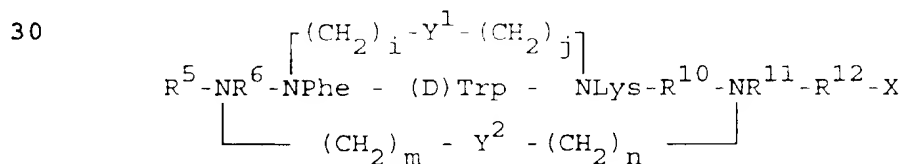
28. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIc):



Formula (XVIc)

20 wherein  $i$  and  $j$  are independently 1, 2 or 3;  $\text{X}$  is  $\text{CH}_2\text{OH}$  or  $\text{NH}_2$ ;  $\text{R}^5$  is absent or is (D)- or (L)-Phe, Nal, or  $\beta\text{-Asp(Ind)}$ ;  $\text{R}^6$  is (D) or (L)-Phe; and  $\text{R}^{10}$  is absent or is Gly, Abu or Thr;  $\text{R}^{12}$  is absent or is Thr or Nal, and  $\text{Y}^1$  is selected from the group consisting of amide, disulfide, thioether, imine, ether, and  
 25 alkene.

29. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIIa):

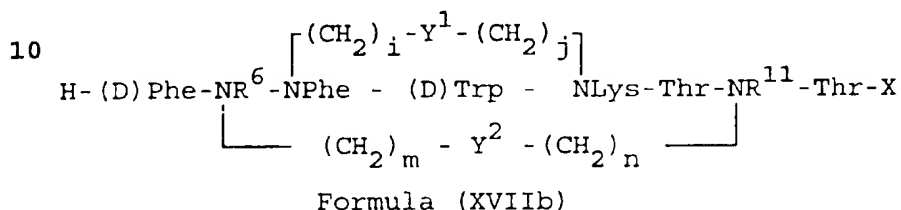


Formula (XVIIa)

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Asp(Ind);  $R^6$  and  $R^{11}$  are independently Gly or (D)- or (L)-Phe;  $R^{10}$  is absent or is Gly, Abu, Val or Thr;  $R^{12}$  is absent or is Thr or Nal; and  $Y^1$  and  $Y^2$  are independently selected from the group consisting of amide, disulfide, thioether, imine, ether, 5 and alkene.

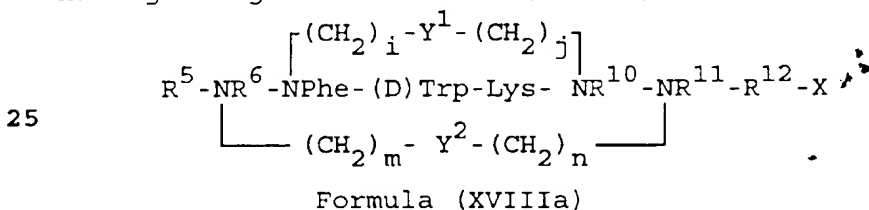
30. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIIb):



15 wherein  $i$ ,  $j$ ,  $m$  and  $n$  are independently 1, 2 or 3;  $X$  is  $\text{CH}_2\text{OH}$  or  $\text{NH}_2$ ;  $R^6$  and  $R^{11}$  are independently Gly or (D)- or (L)-Phe;  $R^{10}$  is absent or is Gly, Abu, Val or Thr; and  $Y^1$  and  $Y^2$  are independently selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

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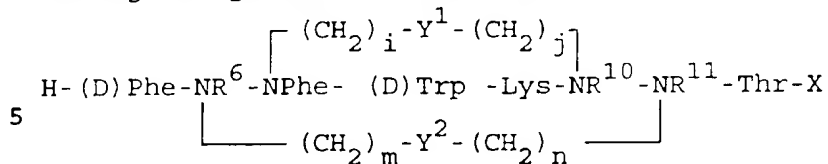
31. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIIIa):



wherein  $i$ ,  $j$ ,  $m$  and  $n$  are independently 1, 2 or 3;  $X$  is  $\text{CH}_2\text{OH}$  or  $\text{NH}_2$ ;  $R^5$  is absent or is (D)- or (L)-Phe, Nal, or  $\beta$ -  
 30 Asp(Ind);  $R^6$  and  $R^{11}$  are independently Gly or (D)- or (L)-Phe;  $R^{10}$  is absent or is Gly, Abu, Val or Thr;  $R^{12}$  is absent or is Thr or Nal; and  $Y^1$  and  $Y^2$  are independently selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

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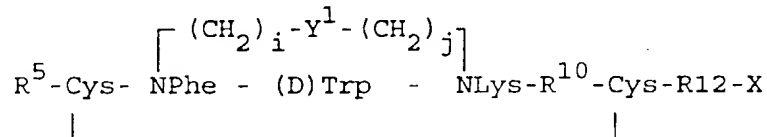
32. The backbone cyclized peptide analog of claim 20 having the general Formula (XVIIIb):



Formula (XVIIIb)

wherein i, j, m and n are independently 1, 2 or 3; X is CH<sub>2</sub>OH or NH<sub>2</sub>; R<sup>6</sup> and R<sup>11</sup> are independently Gly or (D)- or (L)-Phe; R<sup>10</sup> is absent or is Gly, Abu, Val or Thr; and Y<sup>1</sup> and Y<sup>2</sup> are independently selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

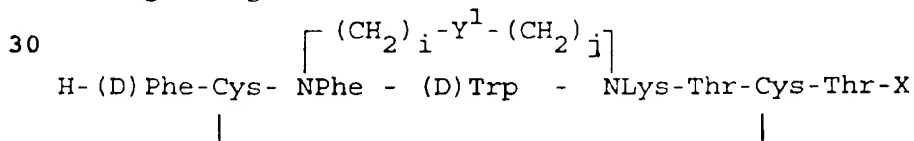
33. The backbone cyclized peptide analog of claim 20 having the general Formula (XIXa):



Formula (XIXa)

wherein i and j are independently 1, 2 or 3; X is CH<sub>2</sub>OH or NH<sub>2</sub>; R<sup>5</sup> is absent or is (D)- or (L)-Phe, Nal, or β-Asp(Ind); R<sup>10</sup> is absent or is Gly, Abu or Thr; R<sup>12</sup> is absent or is Thr or Nal; and Y<sup>1</sup> is selected from the group consisting of amide, disulfide, thioether, imine, ether, and alkene.

34. The backbone cyclized peptide analog of claim 20 having the general Formula (XIXb):



Formula (XIXb)



designates an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same or different; E represents a hydroxyl group, a carboxyl protecting group or an amino group, or CO-E can be reduced to CH<sub>2</sub>-OH; R and R' each designates an amino acid side-chain optionally bound with a specific protecting group; and the lines designate a bridging group of the Formula:

(i) -X-M-Y-W-Z- ; or (ii) -X-M-Z-

wherein: one line may be absent; M and W are independently selected from the group consisting of disulfide, amide, thioether, thioester, imine, ether, and alkene; and X, Y and Z are each independently selected from the group consisting of alkylene, substituted alkylene, arylene, homo- or hetero-cycloalkylene and substituted cycloalkylene; comprising the steps of incorporating at least one N<sup>α</sup>-ω-functionalized derivatives of amino acids of Formula (VI):



Formula (VI)

wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R' is an amino acid side chain, optionally bound with a specific protecting group; B is a protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryl carbonyls; and G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters, aldehydes, alcohols and alkyl halides; and A is a specific protecting group of G;

into a peptide sequence and subsequently selectively cyclizing the functional group with one of the side chains of



38. The method of claim 37 wherein both lines in Formula (I) are present and at least four N'- $\omega$ -functionalized amino acid derivatives are incorporated into the peptide sequence, resulting in a bicyclic compound.

5

39. The method of claim 37 wherein E is covalently bound to an insoluble polymeric support.

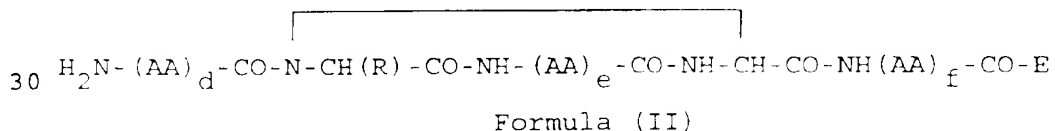
40. The method of claim 37 wherein G is an amine, thiol or carboxyl group.

41. The method of claim 37 wherein R is selected from the group consisting of  $\text{CH}_3-$ ,  $(\text{CH}_3)_2\text{CH}-$ ,  $(\text{CH}_3)_2\text{CHCH}_2-$ ,  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)-$ ,  $\text{CH}_3\text{S}(\text{CH}_2)_2-$ ,  $\text{HOCH}_2-$ ,  $\text{CH}_3\text{CH}(\text{OH})-$ ,  $\text{HSCH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})\text{CH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{NH}_2(\text{CH}_2)_3-$ ,  $\text{HOC}(=\text{O})\text{CH}_2-$ ,  $\text{HOC}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{NH}_2(\text{CH}_2)_4-$ ,  $\text{C}(\text{NH}_2)_2\text{NH}(\text{CH}_2)_3-$ , HO-phenyl- $\text{CH}_2-$ , benzyl, methylindole, and methylimidazole.

42. The method of claim 37 wherein R' is selected from the group consisting of  $\text{CH}_3-$ ,  $(\text{CH}_3)_2\text{CH}-$ ,  $(\text{CH}_3)_2\text{CHCH}_2-$ ,  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)-$ ,  $\text{CH}_3\text{S}(\text{CH}_2)_2-$ ,  $\text{HOCH}_2-$ ,  $\text{CH}_3\text{CH}(\text{OH})-$ ,  $\text{HSCH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})\text{CH}_2-$ ,  $\text{NH}_2\text{C}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{NH}_2(\text{CH}_2)_3-$ ,  $\text{HOC}(=\text{O})\text{CH}_2-$ ,  $\text{HOC}(=\text{O})(\text{CH}_2)_2-$ ,  $\text{NH}_2(\text{CH}_2)_4-$ ,  $\text{C}(\text{NH}_2)_2\text{NH}(\text{CH}_2)_3-$ , HO-phenyl- $\text{CH}_2-$ , benzyl, methylindole, and methylimidazole.

25

43. A method for the preparation of cyclic peptides of the general Formula (II):



wherein d, e and f each independently designates an integer from 1 to 10; (AA) designates an amino acid residue wherein the amino acid residues in each chain may be the same or

OH; R is an amino acid side chain optionally bound with a specific protecting group; and the line designates a bridging group of the Formula:

(i) -X-M-Y-W-Z- ; or (ii) -X-M-Z-

- 5 wherein M and W are independently selected from the group consisting of disulfide, amide, thioether, thioester, imine, ether, and alkene; X, Y and Z are each independently selected from the group consisting of alkylene, substituted alkylene, arylene, homo- or hetero-cycloalkylene and  
 10 substituted cycloalkylene;  
 comprising the steps of: incorporating at least one  $\omega$ -functionalized amino acid derivative of the general Formula (VI):



Formula (VI)

- 20 wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R is the side chain of an amino acid; B is a protecting group selected from the group consisting of alkyloxy, substituted alkyloxy, or aryloxy; and  
 25 G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters or alkyl halides and A is a protecting group thereof;  
 into a peptide sequence and subsequently selectively cyclizing the functional group with one of the side chains of  
 30 the amino acids in said peptide sequence.

44. The method of claim 43 wherein G is a carboxyl group or a thiol group.

25

HOC(=O)CH<sub>2</sub>-, HOC(=O)(CH<sub>2</sub>)<sub>2</sub>-, NH<sub>2</sub>(CH<sub>2</sub>)<sub>4</sub>-, C(NH<sub>2</sub>)<sub>2</sub>NH(CH<sub>2</sub>)<sub>3</sub>-, HO-phenyl-CH<sub>2</sub>-, benzyl, methylindole, or methylimidazole.

46. The method of claim 43 wherein the peptide is  
5 covalently coupled to an insoluble polymeric support.

47. An  $\omega$ -functionalized amino acid derivative of the general Formula:



Formula (VI)

wherein X is a spacer group selected from the group consisting  
15 of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene;

R is the side chain of an amino acid, optionally bound with a specific protecting group;

B is a protecting group selected from the group  
20 consisting of alkyloxy, substituted alkyloxy, or aryl carbonyls;

and G is a functional group selected from the group consisting of amines, thiols, alcohols, carboxylic acids and esters, aldehydes and alkyl halides; and A is a protecting  
25 group thereof.

48. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein X is alkylene.

49. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein G is a thiol group.

50. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein G is a carboxyl group.

51. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein R is benzyl, methyl, or isobutyl.

52. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein G is an amine group with the proviso that R is  $\text{CH}_3$ -,  $(\text{CH}_3)_2\text{CH}$ -,  $(\text{CH}_3)_2\text{CHCH}_2$ -,  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)$ -,  $\text{CH}_3\text{S}(\text{CH}_2)_2$ -,  $\text{HOCH}_2$ -,  $\text{CH}_3\text{CH}(\text{OH})$ -,  $\text{HSCH}_2$ -,  $\text{NH}_2\text{C}(=\text{O})\text{CH}_2$ -,  $\text{NH}_2\text{C}(=\text{O})(\text{CH}_2)_2$ -,  $\text{NH}_2(\text{CH}_2)_3$ -,  $\text{HOC}(=\text{O})\text{CH}_2$ -,  $\text{HOC}(=\text{O})(\text{CH}_2)_2$ -,  $\text{NH}_2(\text{CH}_2)_4$ -,  $\text{C}(\text{NH}_2)_2\text{NH}(\text{CH}_2)_3$ -,  $\text{HO-phenyl-CH}_2$ -, benzyl, methylindole, or  
10 methylimidazole.

53. The  $\omega$ -functionalized amino acid derivative of claim 47 wherein R is protected with a specific protecting group.

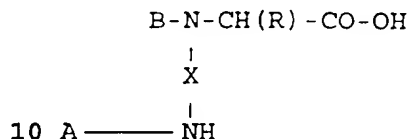
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54. The  $\omega$ -functionalized amino acid derivative of claim 47 selected from the group consisting of:

- a)  $\text{N}^\alpha$ -(Fmoc)(3-Boc-amino propylene)-(S)Phenylalanine;
- b)  $\text{N}^\alpha$ -(Fmoc)(3-Boc-amino propylene)-(R)Phenylalanine;
- 20 c)  $\text{N}^\alpha$ -(Fmoc)(4-Boc-amino butylene)-(S)Phenylalanine;
- d)  $\text{N}^\alpha$ -(Fmoc)(3-Boc-amino propylene)-(S)Alanine;
- e)  $\text{N}^\alpha$ -(Fmoc)(6-Boc-amino hexylene)-(S)Alanine;
- f)  $\text{N}^\alpha$ -(Fmoc)(3-Boc-amino propylene)-(R)Alanine;
- g)  $\text{N}^\alpha$ -(2-(benzylthio)ethylene)glycine ethyl ester;
- 25 h)  $\text{N}^\alpha$ -(2-(benzylthio)ethylene)(S)leucine methyl ester;
- i)  $\text{N}^\alpha$ -(3-(benzylthio)propylene)(S)leucine methyl ester;
- j) Boc- $\text{N}^\alpha$ -(2-(benzylthio)ethylene)glycine;
- k) Boc- $\text{N}^\alpha$ -(2-(benzylthio)ethylene)(S)phenylalanine;
- l) Boc- $\text{N}^\alpha$ -(3-(benzylthio)propylene)(S)phenylalanine;
- 30 m) Boc-L-phenylalanyl- $\text{N}^\alpha$ -(2-(benzylthio)ethylene)glycine-ethyl ester;
- n) Boc-L-phenylalanyl- $\text{N}^\alpha$ -(2-(benzylthio)ethylene)-(S)phenylalanine methyl ester;
- o)  $\text{N}^\alpha$ (Fmoc)-(2-t-butyl carboxy ethylene)glycine;
- 35 p)  $\text{N}^\alpha$ (Fmoc)-(2-t-butyl carboxy ethylene)glycine.

- s) N<sup>α</sup>(Fmoc)(3-Boc amino propylene)glycine;  
 t) N<sup>α</sup>(Fmoc)(4-Boc amino butylene)glycine; and  
 u) N<sup>α</sup>(Fmoc)(6-Boc amino hexylene)glycine.

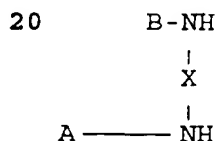
- 5 55. A method of making an ω-functionalized amino acid derivative of the general Formula:



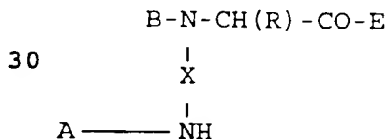
- wherein X is a spacer group selected from the group consisting of alkylene, substituted alkylene, arylene, cycloalkylene and substituted cycloalkylene; R is the side chain of an amino acid; A and B are protecting groups selected from the group  
 15 consisting of alkyloxy, substituted alkyloxy, or aryloxy carbonyls;

said method comprising:

reacting a diamine compound of the general Formula:

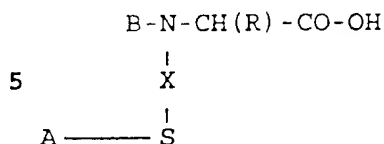


- wherein A, B and X are as defined above,  
 25 with a triflate of Formula CF<sub>3</sub>SO<sub>2</sub>-O-CH(R)-CO-E wherein E is a carboxyl protecting group and R is as defined above; to yield a compound of Formula:



- wherein A, B, E, R and X are as defined above  
 and deprotecting the carboxyl to yield an N<sup>α</sup> ω-  
 35 functionalized amino acid.

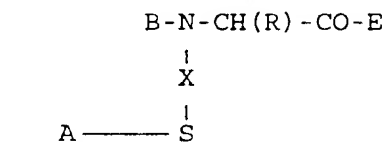
56. A method of making an  $\omega$ -functionalized amino acid derivative of the general Formula:



wherein B is a protecting group selected from the group of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; R is the side chain of an amino acid; X is a spacer group selected from the group of alkylene, substituted alkylene, arylene, cycloalkylene or substituted cycloalkylene; and A is a protecting group selected from the group of alkyl or substituted alkyl, thio ether or aryl or substituted aryl thio ether;

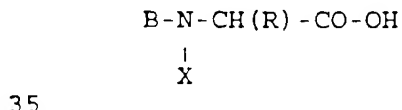
comprising the steps of:

i) reacting a compound of the general Formula B-NH-X-S-A with a triflate of the general Formula  $\text{CF}_3\text{SO}_2\text{-O-CH(R)-CO-E}$  wherein E is a carboxyl protecting group and A, X and R are as defined above, to give a compound of the Formula:



ii) selectively removing the protecting group E, and protecting the free amino group to yield an  $\text{N}^\alpha$ ( $\omega$ -functionalized) amino acid derivative, wherein the  $\omega$ -functional group is a thiol.

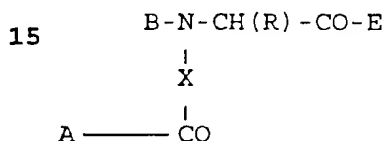
57. A method of making an  $\omega$ -functionalized amino acid derivative of the general Formula:



where B is a protecting group selected from the group of alkyloxy, substituted alkyloxy, or aryloxy carbonyls; R is the side chain of an amino acid; X is a spacer group selected from the group of alkylene, substituted alkylene, arylene, cycloalkylene or substituted cycloalkylene; and A is a protecting group selected from the group of alkyl or substituted alkyl, esters, or thio esters or substituted aryl esters or thio esters;

comprising the steps of:

- 10 i) reacting a compound of the general Formula B-NH-X-CO-A with a triflate of the general Formula  $\text{CF}_3\text{SO}_2\text{-O-CH(R)-CO-E}$  wherein E is a carboxyl protecting group and A, B, X and R are as defined above, to give a compound of Formula:



- 20 and selectively removing protecting group E, to yield an  $\text{N}^\omega$ ( $\omega$ -functionalized) amino acid derivative, wherein the  $\omega$ -functional group is a carboxyl.

- 25 58. A pharmaceutical composition comprising a backbone cyclized peptide analog of claim 13 and a pharmaceutically acceptable carrier or diluent.

- 30 59. A pharmaceutical composition comprising a backbone cyclized peptide analog of claim 14, and a pharmaceutically acceptable carrier or diluent.

60. A pharmaceutical composition comprising a backbone cyclized peptide analog of claim 20, and a pharmaceutically acceptable carrier or diluent.

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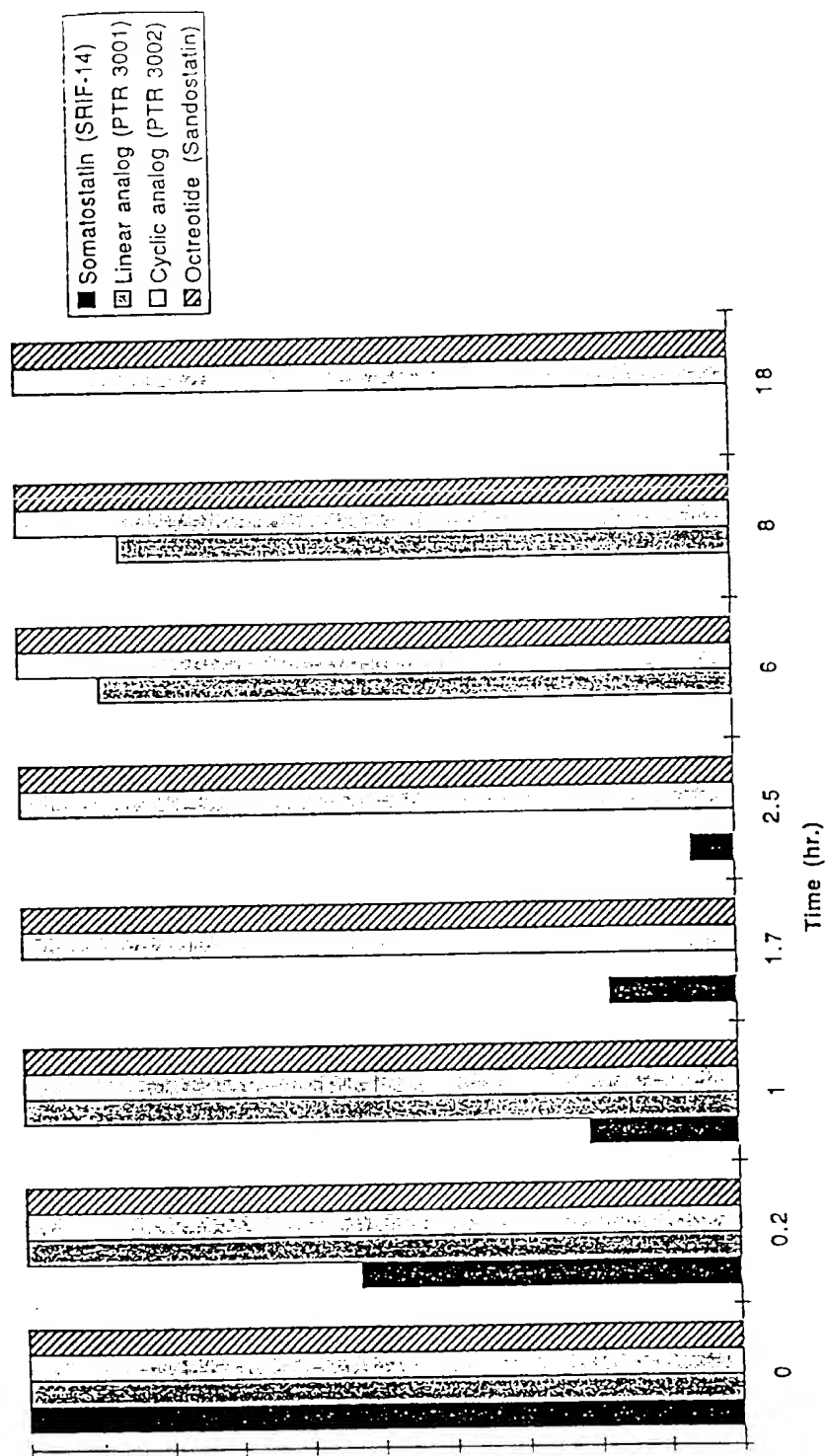


Figure 1.



## INTERNATIONAL SEARCH REPORT

 International Application No  
 PCT/IB 95/00455

 A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 6 C07K7/02 C07K14/655 C07K7/18 C07C271/22 A61K38/04

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07K C07C A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 564 739 (YISSUM RES. DEV. COMP. OF THE HEBREW UNIVERSITY OF JERUSALEM) 13 October 1993 cited in the application see the whole document ---	1,3,4, 47-58
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X	UA,A,3 988 304 (GARSKY) 26 October 1976 see the whole document ---	1,3,4, 58-61
X	FR,A,2 304 352 (AMERICAN HOME PRODUCTS) 15 October 1976 see the whole document ---	1,3,4, 58-61
-/--		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

Date of mailing of the international search report

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Masturzo, P

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/IB 95/00455

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	WO,A,94 11393 (SALK INSTITUTE) 26 May 1994 see the whole document ---	1-61
X	DE,A,41 19 544 (GBF) 15 October 1992 see the whole document ---	47-57
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Information on patent family members

International Application No

PCT/IB 95/00455

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